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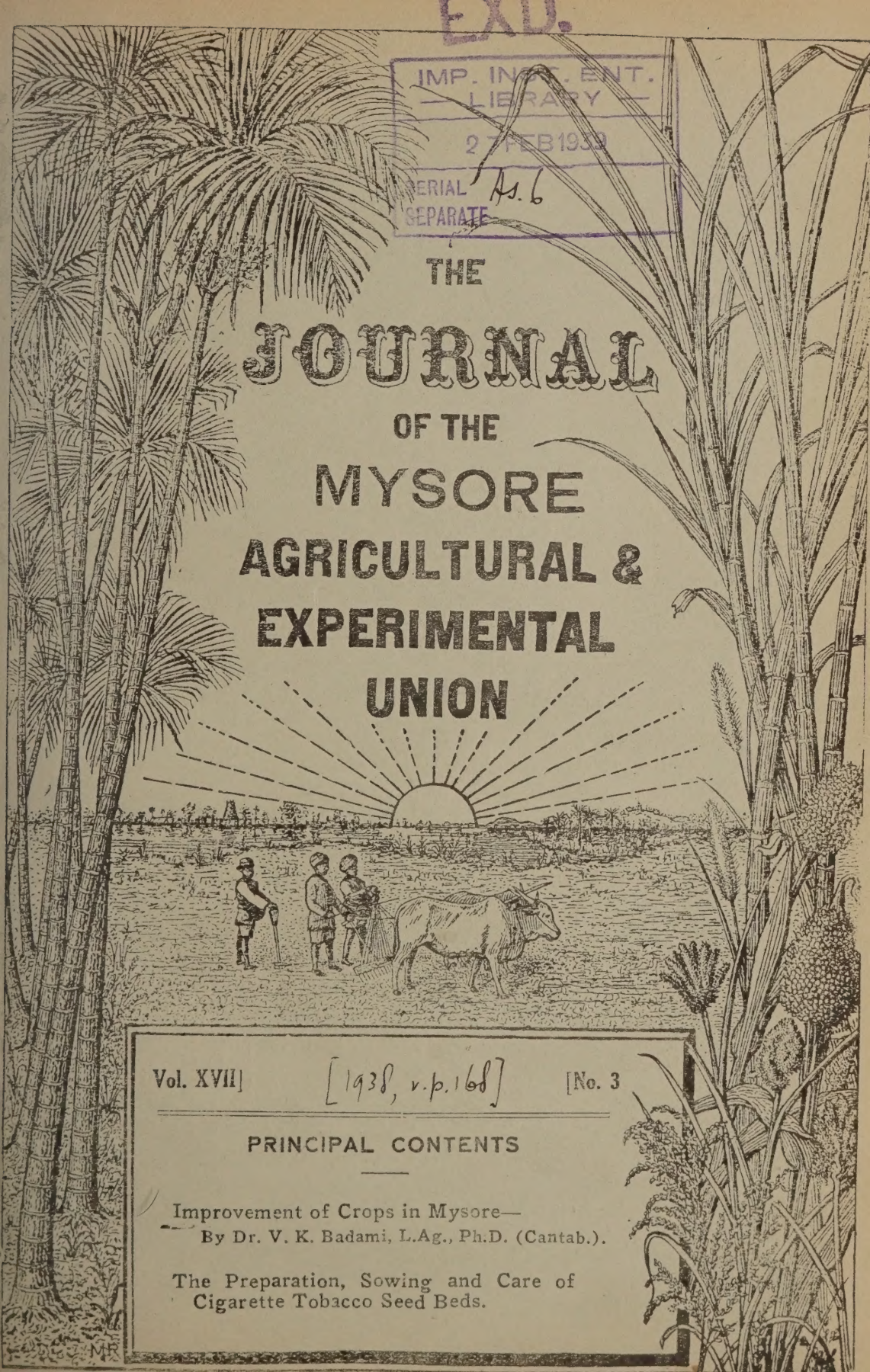

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Improvement of Crops in Mysore

(A Review of Twenty-five Years' Work)

By

Dr. V. K. Badami, L.Ag., Ph.D. (Cantab.)
Deputy Director of Agriculture in Mysore

For over a century and a quarter, new varieties of plants, flowers, vegetable seeds and economic crops of importance have been imported and tested by the Department of Government Gardens. To a great extent the wealth of the flora of the State has been enriched by the work of that Department. A good herbarium was built up and many coloured drawings of rare flowers, plants and fruits have been made. Two valuable books were published describing the flora of Mysore.

Introduction of new crops and seeds of promising varieties of staple crops was being made ever since the "Model Farm" was started near Lalbagh in Bangalore over fifty years ago. Mr. A. Rangaswami Iyengar, Revenue Commissioner, successfully introduced early maturing strains of paddy into Mysore. Since the inception of the Agricultural Department and the establishment of the Hebbal Farm this

work has been carried on in a systematic manner. During Dr. A. Lehman's regime Java seedling sugarcanes, B. 208 and White, Striped and Red Mauritius canes, were introduced and tested on a large scale. Java and Red Mauritius canes are still grown to some extent in the Malnad Taluks.

Systematic plant breeding work was organised by Dr. L. C. Coleman after the re-organisation of the Agricultural Department in 1914. The Botanical Section has now separate farms for carrying on breeding work, on paddy at Nagenhalli and *Kar Ragi* and *Kar* crops at Hunsur. Portions of other farms are set apart for breeding work on other important staple crops. On the Hebbal Farm, work on the breeding of ragi, sugarcane, groundnuts, castors, potatoes and grasses is in progress; work on the improvement of cotton, cocoanut and jola (*Andropogon sorghum*) is conducted on the Babbur Farm. There is a subsidiary farm at Singapur Kaval for working on American types of cotton under rain-fed conditions. Malnad paddies are being improved on the Marthur Farm. On the Irwin Canal Farm all new introductions are tested.

The Central Laboratory at Bangalore is well equipped and the large breeding cage provides facilities for carrying on critical breeding work under controlled conditions. Seed testing and cytological investigations are carried on at the Laboratory. The staff has been greatly strengthened. Often, many research students are admitted to work on special problems and many of them have found employment in various institutions in India.

SUMMARY OF THE RESULTS OBTAINED AND THE PROBLEMS STILL AWAITING SOLUTION ARE BRIEFLY DESCRIBED UNDER EACH IMPOTANT CROP IN THE STATE

1. *Ragi* (*a*) *Hain Ragi.*—Cultural experiments conducted on the Hebbal Farm over a series of years have given the following results:—

(i) Ploughing with a mould board plough gives a better yield of ragi than ploughing with a country plough.

(ii) Ploughing soon after harvest gives a better yield than ploughing in spring.

(iii) Ploughing-in green manures is beneficial and a crop of cowpea ploughed in is better than sann-hemp or ordinary farmyard manure.

(iv) A rotation of legumes with ragi is highly desirable and a groundnut crop gives the best results.

(v) Growing a pure crop of ragi is better than having lines of *avare* and other crops—for it facilitates timely ploughing and cultivation.

Over 300 collections were made from various localities in the State and studied. They were grouped into about a dozen classes. The best of them have been maintained as standard types for the purpose of comparison. A number of varieties from other parts of India and Africa was collected and tested. Most of the varieties were found to be mixtures. They were purified to the type and tested. Under Hebbal conditions which represent the *Hain* ragi area, the local *Hullubele* has given the best yields in the collection of varieties and it is now used as the standard variety.

The following observations were made in the varieties:—

(i) Varieties with small ear-heads tillered freely and usually possessed thin straw.

(ii) The bigger and heavier the ear-heads in a variety, the fewer were the tillerings.

(iii) In general, open ear-headed varieties were more suited to droughty conditions and compact headed varieties to moist situations or heavy rainfalls.

(iv) A pure type gave higher yields and reached maturity uniformly resulting in the production of high grade seeds.

(v) Continued selection of ear-heads increased the size and number of spikes in the ear-heads, but a continuous selection was found to be necessary to keep up the improvement.

Plant selections were made on a large scale in 1913 and their progenies were studied in succeeding years. Many selections were found to be superior to the varieties from which they were selected. The best of these in each variety were grouped together and tested in the plots from five to ten years and the most promising ones were tested against the local Hullubele for yields. Those that were found superior to the standard local check, were tested in various localities and promising ones were multiplied and distributed to the ryots. The most popular ones were, H.22, H.2, H.13, H.40 and H.44. Out of these only H.22 and H.2 remain as favourites. H.45, H.55, H.75, H.80 and H.92 are promising in the trial plots and they await testing in the villages before release for general distribution.

H.22, the most popular variety, is the one improved type which has spread over several hundred thousand acres in the State and in the bordering districts of the Madras Presidency. "A" grade seed farms produce pure seed in large quantities and these are multiplied in the "B" grade seed farms by the district staff for general distribution. These seed farms are opened on private estates. To encourage influential ryots to open seed farms, they are paid a premium of 10% on the market price of the seed purchased from them. H.22 has given 20 to 30 per cent. more yield than the local varieties in many places. Its drought resistance, heavy yield of good grain and a large amount of straw, have made it a popular variety in the State.

(*b*) *Kar Ragi* (*Kar area*).—Early sown ragi is generally found in the south-western part of the State. Over 300,000 acres of it are sown annually. It is sown in April or May and harvested by September. *Hain* ragies, when sown in the *Kar* area, will not ripen before the rains are over. If the rains hold off in the north-east monsoon, the *Hain* crop will be a total failure. Early experiments at Mysore and Nanjangud showed that the *Kar* ragi crop required a good deal of improvement in the methods of cultivation, manuring and sowing. The universal practice of sowing by braodcasting takes more time than that by

drills. The ryot has only the "plough" for all his cultural and sowing operations in this tract. But there is very good scope for the introduction of drills, harrows and cultivators.

Preliminary experiments showed that—

(1) drilling seeds in rows gave higher yields for all varieties;

(2) broadcasting gave more straw;

(3) compact earheaded varieties had the heaviest earheads; and

(4) violet open earheaded variety gave the highest yield.

Plant selections and testing of varieties were continued from the material collected before; and further selections were made in the districts after the Kar Ragi Breeding Station was opened at Hunsur in 1928.

Out of the many promising selections violet compact variety, H.K.13, is very promising. It is closely followed in yield by a green compact type, K.1. These two do well in most of the soils and produce much heavier yields than the local *Kar* ragi mixtures. But, for richer and moister soils, H.K.82 is better suited. It takes a slightly longer time to mature but heavy yields of grain and straw are obtained. These new varieties indicate that by sowing improved strains it is possible to obtain in the *Kar* areas yields as high as those of the *Hain* tract.

(*c*) *Garden Ragies.*—Under irrigated conditions it is possible to manure heavily and secure higher yields of 15 to 20 *pallas* of ragi per acre. Varieties with many branching ear-heads such as H.41 and H.42 which do not tiller well may be transplanted closely for securing high yields. K.1 and *Kar* ragi selections can be transplanted at any time of the year before the seedlings are 30 days old. The *Hain* ragies H.41 and H.42 can be planted only in the *Hain* season. It always pays to transplant on ridges, the furrows being used for irrigation. Much propaganda is needed to persuade the ryots to give up the system of flooding the square beds. Ragi does not tolerate water-logging.

2. *Paddy.*—Paddy is grown on nearly three-fourths of

a million acres of land every year in the State. With the expansion of irrigation facilities more areas are being brought under cultivation. Paddy is grown under heavy rainfall conditions in the Malnad, under canals drawn from perennial rivers and under numerous tanks. Scores of varieties are grown in the State. Coarse types are grown usually in the Malnads. These are fit for preparing parboiled rice. Under the canals, coarse, fine and medium types are grown. Below the tanks, under *punaji* system of cultivation, coarse varieties are grown. Most of the summer varieties are coarse. In the Cauvery valley the following are some of the best varieties largely grown, *viz., Kaddi, Kembuthi* and *Pattasamanahalli. Maralakanthi, Bolamallige, Alur sanna* and *Doddabyra* are the most popular varieties grown in the eastern part of the State under tank-fed conditions. In the Malnads, *Jaddu, Hasadi, Walya, Togarina, Hegge* and *Dabbanasale* are well known. Among the summer varieties, *Halubbalu* is very popular. Fine-grained varieties are grown in several places. *Kempuraja, Natanahalli sanna, Yelandur sanna, Bangara theega, Gunasale* and *Gandasale* are the well-known varieties grown in Mysore.

Many varieties tested on the various farms showed promise but on release for distribution they did not prove the success that was hoped of them. The conversion of the Nagenhally Farm into a Paddy Breeding Station in 1929 provided facilities for systematic work. Over 300 varieties have been collected from different experimental stations in and outside India. In the first instance, they were all purified and the pure strains were tested for yield. None of the introduced varieties was found to be superior to the local variety either at Hebbal, Nagenhalli or at Marthur. A selection from Coimbatore Paddy Station introduced in 1920 has spread very widely all over the State on account of its fine grain, high percentage of rice and non-lodging stand on the field. Its yield of grain and straw is rather disappointing. On account of its good milling quality and high prices it has begun to spread widely even in the

Malnad areas though the yields are not so high as the local coarse rices and the common *Dabbanasale*. Nearly 400 *pallas* of pure seeds of G.E.B. 24 are sent out from Nagenhalli annually. As the demand is very great it is now being multiplied on the Irwin Canal Farm for distribution. In the eastern taluks and round about Bangalore, *Gunasale* is popular. In the summer crop areas, *Basumathi, Kempuraja, Chintamani sanna* and *Halubbalu* are very successful.

Over 300 collections are grown in the observation plots on the Paddy Breeding Station. Nearly a hundred of them have been tested for yield. Experiments conducted over several years have shown that the right age for transplantation of seedlings is when they are 30 days old. That is the standard age at which all varieties are transplanted now. Twelve varieties were found to be early ripeners, being ready for harvest in 80 to 100 days after transplantation. Of these, two are fine and the rest coarse. The finest amongst local ones are *Bangarkaddi* and *Yelandur sanna*. About 30 varieties were found to ripen in 100 to 110 days after transplantation. Among them six are fine varieties, *Basumathi, Kempuraja* and *Chintamani sanna* being the best of them. There are 15 varieties which take a medium duration of 110 to 120 days to ripen after transplantation of which only two, *Alur sanna* and *Natanahalli sanna,* are fine types, the rest being coarse. Among the late-ripening varieties which take between 120 and 130 days to ripen, there are 20 varieties of which seven are fine and thirteen coarse. It is only in this group that fine varieties with high yielding capacities are present. The most promising ones are *Maharajabhoga, G.E.B. 24, Delhiprayag* and *Byhunda*. Eight varieties were found to be very late ripeners, taking over 130 to 150 days to be ready for harvest. There were no coarse types in this group. They give heavy yields of grain and straw and are well suited to localities having irrigational facilities for over six months. Medium grained ones are *Kembuthi, Pattasamanahalli, Kaddi* and *Rangoon Red*. The fine ones are *Nagpur sanna* and *Sakalati*.

In general the coarse varieties give higher yields. Most of the varieties on an average yield a low percentage of grain to paddy. To combine high yields of grain and straw in finer varieties, many plant selections have been made and tested. As a result of such work several strains have been isolated and multiplied for distribution. About 30 selections were promising in the test plots. Out of them S.169, a *kaddi* selection, S.67, a *kembuthi* selection and S. 236, a Nagpur selection have been found to do well in several places and they are slowly spreading. S.236 which has a finer grain than G.E.B. 24 is much in demand. The following new strains are full of promise and require to be tested in the districts before they could be released for general distribution:—

Pattasamanahalli selections	S.363, S.364, S.476, S.477, S. 590 and S. 581.
Alur sanna selections ..	S.197 and S.199.
Nagpur sanna selections ..	S.574 and S.248.
Gunasale selection ..	S.268.
Maharajabhogam selections ..	S.615, S.617, S.624, S.625 and S.657.
G.E.B. 24 selection ..	S.661 (to be distributed as improved G.E.B. 24).
Do. hybrids ..	Segregates—4, 18, 27, 50, 194, 478 and 514.
Halubbalu selection ..	S.317.
Banku selection ..	S.328.

Improvement of Malnad paddies was taken up only in 1929. Previous to that year a collection of local strains was made and tested for over 10 years and on several occasions the stock was purified by roguing out mixtures. In the tests *Musalli, Mullegge, Walya* and *Hosahalli bili* have given from 25% to 40% more yield of grain than G.E.B. 24, but the finer grain of G.E.B. 24 is much in demand by the mills. The spread of this fine variety will seriously affect production of grain and straw. Five Java varieties, *Gabah Skivimankotti, Gabah Tongsan, Gabah Tjena, Gabah Temas* and *Gabah Rosaki* have been failures in the area. Out of the

large collection in the Rice Breeding Station at Karjat in Bombay a collection of 52 varieties was made and tested at Marthur. A large number of them are early ripeners and unsuited to our *malnad* conditions. Four of them *M. Burma I, S.G. 114, Ramasal* and *S.G. 226* have been very promising producing larger quantities of grain and straw than G.E.B. 24. Burma 355 has given over 6,360 lbs. of straw. In the *malnads* where the fodder problem is acute, yield of straw is of great importance, especially so when the local varieties do not yield more than 2 or 3 thousand pounds of straw.

A large number of plant selections were made in all the varieties and tested. About 40 of them were found promising. The following eight strains have given over 30% to 60% more yield of grain than G.E.B. 24, which are being tested on the farm for release to the ryots: Ho. 1129, Ho. 1329, W.529, Ho.829, H.B.1729, Ho.1629, H.B.1929 and W.429. Earlier selections Ho.529 and W.3629 have done well on the ryots' fields. Large-scale demonstrations and production of sufficient pure seed for seed distribution are necessary now.

Much work remains to be done on summer paddies. A list has been prepared at Hebbal to show that a large number of paddies grown in the monsoon are not suitable for summer cropping as they only produce vegetative growth at the time and never flower and set grain. A testing station is necessary in Kolar District. At present only the following varieties are recommended for the summer crop: *Basumathi, Kempuraja, Chintamani sanna* and *Halubbalu.*

Cooking tests have been conducted with over 150 varieties and it is found that in general the finer varieties absorb more water and expand more than the coarser varieties. Nutritive values of coarse and fine varieties require to be investigated early before replacing the Malnad varieties by improved strains.

Transplanting in the Maidan areas and sowing in drills in the malnads seem to be the most profitable methods. Thin sowing in seed beds and transplanting one to three seedlings

6 in. to 9 in. apart of 30 days' seedlings is the method which has given the best yields. New strains planted in fields well manured with about two to four tons of green leaves and a complete mixture of N.K.P. artificials have given very best yields of grain and straw.

3. *Jola.*—Jola is an important food grain in the State. Over 220,000 acres are under cultivation in the *mungar* area round about Mysore and nearly 300,000 acres of *hingar* crop is sown in the black cotton soils of Chitaldrug, Shimoga and Tumkur. No work has been done on the improvement of the *mungar* crop. Over 60 varieties were tested on the Hunsur Farm but this locality is not suited for the jola crop. There are about six main types varying in the compactness of heads and the colour of the blooms. Plant selection in the ryots' fields was started in 1937. These selections will be tested on the Irwin Canal Farm along with the selections obtained from the Millet Station of Coimbatore. Over 60 collections have been maintained on the Babbur Farm for over 20 years. Preliminary observations and many ear-head selections have been made from time to time. Nine varieties stated below are promising: *Bili* jola of Gannaikanhalli, Chitaldrug jola, *Bili* jola, Sorghum No. 2, *Maldandi*, *Shahabad Jawari*, *Doodia* and *Lamshai*. Out of them some plant selections have been made and Gannaikanahalli No. 57 and No. 34, *Bili* jola No. 33 and *Maldandi* are the best. They require to be tested in the fields before distribution.

Fodder jolas are very popular in Mysore. *Kaki* jola is largely grown in the *mungar* season. Two types, compact and open head are grown in lines as a mixed crop with *Hain* ragi and *Bili* jola is grown largely in the *hingar* season. Large quantities of *Bili* jola seed are tested and distributed to ryots during seasons of drought by the Department. *Sundia* jowar has been successfully grown as an early ripening fodder crop on the Hebbal Farm. Plants have been found to vary in sugar content from 4% to 15% in American sugar sorghums. Plant selections have been made to establish fodder jolas with a high sugar content.

African Kafir corns, Durrums and Milos have been tested on the Hebbal Farm and found unsuited to our seasonal conditions.

On the Irwin Canal Farm many early ripening varieties of jola were tested under irrigation. Selections out of *Chitrai cholam* from Coimbatore Millet Station are promising. One of them is now being multiplied for general cultivation during the summer months.

4. *Sugarcane.*—Work on sugarcane in Mysore has shown what organised effort and working to a plan can do to help an industry. Cultural experiments, manurial requirement of the crop and the breeding of improved varieties were in progress and had yielded valuable results before the sugar industry received an impetus from the protective duty. It was therefore possible to extend sugarcane cultivation and establish a factory in an amazingly short time. During the very first year it was possible to declare a fairly good dividend.

The original canes in Mysore were *Cheni* and *Marakabbu*. They were both hard-rinded reed canes. *Rasthali* was grown to some extent. It was a thick cane but was not rich in sugar. About 150 years ago *Pattapatti* cane was introduced into Mysore by the officers of Hyder Ali from the Karnatic Plains and improved methods of cultivation were introduced by the French settlers from Mauritius. Sugar was prepared at Ganjam near Seringapatam. By 1850 a sugar refining factory was established at Palahally and the sugar prepared by the Ashtagram Sugar Company, won medals in the two great exhibitions at Crystal Palace, London. Later, the sugar factory started at Goribidnur worked successfully for a long time. Dr. Lehman did yeoman service to the State from 1898 to 1908 in threshing out the various problems connected with sugar-making, jaggery-making and the cultivation of sugarcane by improved methods. During his time, White Mauritius, Striped Mauritius, Red Mauritius, Java, Elephant cane and B.208 were introduced. None of them was economically superior

to the rich Mysore *Pattapatti cane*. B.208 was a rich cane but it had a poor growth. Java was an early rich cane but it flowered freely and gave low yields. Java and Red Mauritius canes are still grown to some extent in the Malnad taluks.

Preliminary cultural experiments have shown that planting in continuous rows 3 to 4 feet apart gave the best yields and reduced the seed rate. Planting in furrows a foot deep and gradually filling up the furrow as in Java has given higher yields and prevented lodging of canes. Wrapping and tying of clumps encourage better growth protecting the canes against the sun and the ravages of jackals and permit clean cultivation. Heavy manuring is necessary for harvesting good crops of sugarcane. Three tons of groundnut cake gave better result than castor or *Honge* cake. Heavy doses of ammonium sulphate of even over 10 cwt. per acre have been applied and crops of over 80 tons to the acre have been harvested. The land requires a thorough cultivation and a heavy dose of compost or organic matter to the extent of 30,000 lbs. per acre is necessary as a basic manure. Heavy doses of ammonium sulphate based on the fertility of soils tempered with 2 to 4 cwts. of super will produce good cane crops with rich juice in the cane, in about a year.

Dr. Lehman found that by adding lime to the cane juice to neutrality and removing the scum while the juice is boiling, good, clean and hard jaggery could be prepared. Recent researches in India have shown that by the use of activated carbon, jaggery with a light cream colour could be prepared. With slight modifications the Chemical Section has been able to evolve methods of making such jaggery which the ryots can easily adopt. Intensive work was done by Dr. Lehman in connection with sugar-making in the open pans and centrifugals. It was found possible to prepare good white sugar and an inferior kind of jaggery from the molasses but economically it was not a paying method. So long as there was a good market for jaggery, it was not paying to prepare sugar in the open-pan system. The market

for the inferior kind of jaggery from molasses was found to be very much restricted. Researches were therefore directed to the production of vigorous rich canes, to the improvement in the methods of cultivation and irrigation and to the improvement in the method of making good jaggery which would not run during the monsoon rains.

Improvement of sugarcane by raising seedlings was started in Coimbatore, in 1911 and 1912 and plenty of material was collected in Mysore for that work in 1913. It was found that the Mysore plateau was congenial for the cane to flower and set seed. Evolving of new seedling canes was started in 1913. While Coimbatore confined its activities to the evolution of canes for Northern India and hybridization work of combining desirable characters suitable to the conditions existing there, Mysore confined herself to the evolution of thick tropical canes to suit the local conditions. All the exotic and indigenous canes of India were collected and the standard collection thus made has been maintained all along. The best known canes from the important centres of sugar production are found in the collection. They afford material for comparison and breeding work. Most of the canes which produced fertile flowers and set seed proved to be highly heterozygous in character and a wide range of variations were found in the seedlings raised. This advantage has been fully utilised in raising a large number of seedlings for making selections. Most of the exotic canes flower between September and January and set seed in about a month. Methods were perfected to raise seedlings successfully on a large scale for field work and most of the canes were studied as to their suitability as parents in breeding work. B.208 and Barbados canes produced rich seedlings but they had no vigour. Demarara and East Indian canes produced seedlings with a wide range of variations but so far, seedlings with great vigour and high sucrose have not been obtained. Similar results were obtained in Mauritius canes. But the vigorous Red Mauritius cane produced a large number of non-arrowing seedlings of great vigour. A few of them had a high sucrose content and such varieties were selected for

yield tests. These seedlings varied in their morphological characters and agricultural qualities. Good tillering habit, vigorous growth, yellow or orange colour, striping habit of leaves, absence of bristles on the leaf-sheaths, erect growth and non-lodging habit were the points which were studied in making the selection. Non-flowering canes produced the greatest tonnage of canes as they had a full period of growth of ten months and a ripening period of two months. If the seedlings flowered early, vegetative growth was arrested and the tonnage reduced. On the other hand, if the canes flowered after ten months or as late as possible in the season, the growth was not checked and heavy yields were obtained. But in such cases the value of tops as fodder is lost. The ideal for Mysore conditions is a non-arrowing cane which ripens in twelve months, gives an extraction of 70% in a bullock power mill and has a sucrose content of over 20% and a low glucose value of below 0.2%. Under good cultivation the yields should go up to 50 to 80 tons per acre. On this basis all the selections have been made. Seedlings like H.M.544, H.M.320, H.M.312, H.M.553, H.M.315, H.M.89, H.M.87, H.M.14 and H.M.600 were promising and they were tested in the districts for yields. H.M.544 and its striped bud sport spread widely in the State, giving over 50 tons on good heavy soils. It was found to be a fourteen months' cane and it has rapidly given place to the more productive H.M.320 which ripens in 12 months and has a richer juice. H.M.553 is popular in Chitaldrug District and in parts of Malnad. H.M. 544 and H.M. 320 have spread over the Bombay Presidency in the canal areas as ryots' canes. H.M.87 has come to stay in Konkan. H.M.320 and H.M.608 have spread in Janjira State and some of these have been successfully grown in Hyderabad. In Mysore H.M.320 has spread over twenty thousand acres in the districts as the most suitable cane for the ryot and it is at present the principal cane feeding the Sugar Factory at Mandya. Ten to fifteen thousand acres are said to be grown round the Factory. It has become an all-round cane, being planted in every month and allowed to grow from twelve to

eighteen or even more before it is harvested for the Factory. The sugar recovery in the Factory is said to have varied between 10% to 12% on the weight of cane.

There was a break of about five years in sugarcane breeding work and, in 1928, it was renewed by raising a large number of fresh seedlings from various parents. Out of them a large number of seedlings obtained by crossing H.M.544 and P.O.J.213 were secured. Many of them have proved to be vigorous and rich in sugar. They have over 13% of fibre and do very well on poor gravelly or water-logged or saline soils. A few of them like H.M.607 and H.M.609 resist drought very well. H.M.606 evolved by in-breeding selected seedlings of Striped Mauritius cane is promising. It is doing well at Padegaon. H.M.608, another cane evolved by in-breeding strains of seedlings from Striped Mauritius, has given the richest juice in our seedling work. It does not flower and is erect. When it is fourteen or fifteen months old the juice shows a brix content of over 28% and a sucrose of 25% to 26%. The percentage of glucose is only about 0.07%. Such canes have been multiplied for tests and distributed to various parts of India, South Africa, Formosa and the United States of America.

Evolution of new seedlings has a great future before it. Within 6 years after the evolution of the first batch of seedlings, over several hundred acres were under them and at the present time the indigenous canes have been displaced almost wholly by the improved varieties of seedling canes. These seedlings have helped to a great extent the success of the Mandya Sugar Factory which crushes nearly 1,500 tons of cane a day and works for a larger number of days than any factory in India.

While the breeding work was in progress in the State the Department was in close touch with other sugarcane breeding stations. The improved sugarcane seedlings from Coimbatore have displaced over 75% of the indigenous canes in Northern India. A large collection of the most promising ones have been obtained and tested at Hebbal. They are all

medium or thin canes having a high sucrose content and early maturing habit. Under our conditions they flower early in September or October and become very pithy before the next planting season. The following have done fairly well at Hebbal and they will be tried on field scale on the Irwin Canal Farm: Co.205, Co.213, Co.281, Co.290, Co.313, Co.360 and Co.419. Out of them Co.290 seems to be well suited for saline and heavy water-logged soils. Co.360 and Co.419 require to be carefully tested. The sugarcane sorghum hybrids flower very early and produce arrows with long stalks. The yields are very low and they are of no economic value to Mysore. Seedlings of outstanding merit from Hawaii and Java have also been secured and tested. H. 109, a seedling from Hawaii, which has given over a hundred tons of cane in that place, flowers early at Hebbal and gives very low yields. P.O.J. 2878, the famous seedling cane of Java, has been an early flowering cane here, with a low production when planted in the main season in January. If it is planted in June or July it grows well in the canal area producing over 40 to 50 tons of cane as it skips over the first flowering season and has a long period of growth. But H.M.320 planted in the same season gives a higher yield. P.O.J. 2878 has a rich juice but it is known to be difficult to clarify. It cannot replace H.M. 320 as a cane for all seasons. Other Java seedlings P.O.J. 100, P.O.J. 2883 and P.O.J. 2725 are not satisfactory. All these seedlings have set seed freely and provide material for further work. Many vigorous rich seedlings have been already obtained from P.O.J. 2878 and Co. canes and they are being tested for their productiveness.

The introduction of a large number of seedlings into the State introduced the mosaic disease along with the seedlings. At one time in 1935, the spread of the disease on H.M. 320 cane caused great anxiety, but this cane was discovered to be highly tolerant to mosaic. By rigorous seed selection and planting only healthy material, the spread of the disease has been checked and the disease itself has been brought under control. New seedlings raised from P.O.J. 2878 seem

to be quite resistant, or free from mosaic in addition to being heavy yielders with rich juice. The destruction caused by the borer has been effectively kept under control by the wasp parasites *Trichogramma* and by earthing up the furrows when the canes are still young.

In 1938 the Imperial Council of Agricultural Research sanctioned a sum of about Rs. 21,000 spread over five years for breeding work on thick sugarcanes. With this subvention, one Senior Assistant Botanist and one Junior Assistant Botanist were appointed to help the Economic Botanist in cane-breeding work. An X-ray apparatus also was specially got manufactured for the purpose of treating sugarcane buds with X-rays to induce bud mutations. Local *pattapatti* cane was selected for X-ray treatment. In the apparatus used, the usual 220 volts are converted into 60,000 volts and for working energy, from 60 k.v.p. to 90 k.v.p. were used. The ampearage varied between 5 m.a. to 10 m.a. A large number of single buds were germinated and treated under exposures varying from half an hour to three hours. It was possible to obtain over 40% of mutations in the treated material. The mutants varied in colour, size, vigour and sugar content. From the banded *pattapatti* cane, red canes, yellow and orange canes, with various shades, thick and medium canes have been obtained. Many of them vary in vigour. The sucrose content varied from 15% to 22%. Some mutants arrowed and set seed. These results show that by using an external physical energy it is possible to bring about changes in the structure and character of chromosomes and genes and bring about variations. Some of the canes thus evolved are far superior to the parent *pattapatti* in vigour and possess bright yellow golden colour. All such mutants have been termed "Mysray" with numbers. The success of the work opens up a new line of investigation in plant-breeding. It could be used with all plants which do not flower or set seed, like potato and plantain. Bud variations can be induced in fruit and flowering plants. Sugarcane breeding work can be taken up in temperate climate where the cane does not flower and set seed. There

is a likelyhood of South Africa and Formosa following our work. At present the X-ray energy has been used to induce variations in H.M. 320, Red Mauritius, Q. 813, H.M. 544, H.M.89 and a number of striped canes. Sir John Russell, Director of Rothamstead Experimental Station in England and Agricultural Expert Adviser to the Government of India, who was deputed to inspect this work and report on it, has, among other remarks, made the following observation:—

> "Beside the plant breeding on the classical lines proceeding at Coimbatore, a special method involving mutilation or destruction of some of the chromosomes by X-rays is being tried by Dr. Badami at Bangalore and whether this produces better sorts or not, it promises to give new material of possible value for the breeder".... "X-ray treatment of sugarcane seeds in Trinidad, Hawaii, Mauritius and Java does not seem to have yielded results, but Dr. Badami attributes this to their using seeds from heterozygous canes."...."Work by Dr. A. E. Murneck on bud variations in the apple caused by X-ray is recorded by Staedler (*Journal of Heredity*, 1930, Vol. 21, pp. 3–19) but I know of no work on sugarcane buds comparable with Dr. Badami's."

This scheme was sanctioned in the first instance for five years. It has now been extended for another year pending further sanction for continuing breeding work on a large scale on the Irwin Canal Farm.

5. *Groundnut.*—The groundnut crop is in cultivation for a long time. A long duration variety known as Mysore nut was being grown as a garden crop even before 1850. It has a long pod with a large number of seeds varying from 3 to 7. This has a low percentage of oil. With the spread of Mauritius varieties in Madras, groundnut became a field crop in Mysore also. Before the Great War, there were about 50,000 acres under this crop and large quantities of oil were imported. Till 1916 the total area under groundnut was not separately shown in the reports and in 1929 it had

increased to 323,738 acres. It is now fluctuating round about 200,000 acres. The extension has been rapid due to the introduction of new varieties, specially of the short duration strains getting into cultivation. In Chitaldrug District where formerly there was no cultivation of the crop, from about 20,000 acres in 1915 it had spread to over 100,000 acres. The amazing progress may be judged by the progress made in the Taluk of Honnali. From 30 acres in 1915 the area has now increased to over 10,000 acres. In extent and importance, groundnut has outstripped cotton in Chitaldrug and in the State. Area under cotton has dwindled down from 1,20,000 acres to about 80,000–90,000 acres. The value of the groundnut crop at the present prices may be roughly put down at Rs. 70 lakhs as against Rs. 25 lakhs of cotton. Cultivation of *Sanhatti* cotton is confined to the black soil area in the North. *Nadam* type of cotton is grown to a small extent in the south-eastern part of Mysore District. Unless suitable types of American cottons are evolved for growing under irrigation or for growing as a dry crop on red and sandy soils there can be no further extension of cotton crop in the State. While investigations on the improvement of cotton on these lines are in progress, groundnut has established itself as a very important commercial crop in the State. It has been definitely shown that groundnut cake has a higher nutritive value as a human food like soya-beans, and it is said to be superior to it being more easily digestible. In a country where cereals form the bulk of the food and the feeding value of the daily food is poor, as a cheap and efficient source of proteins required, groundnut deserves serious consideration. As a feed for animals and as manure for commercial crops, groundnut cake is largely used in the State. Bearing these factors in mind the Department organised the testing and distribution of varieties in the districts. In the course of about 15 years a crop of no consequence has become a major and a very important commercial crop. There is much scope for further extension and improvement of the crop and the Department has organised research to help the industry. The introduction and extension of this crop has

been one of the successful efforts of the Agricultural Department in Mysore.

Extension of groundnut cultivation need not cause anxiety about the production of food grains. Experiments on the Hebbal Farm have shown that when groundnut is grown in rotation with ragi there is an increase of ragi grain production by about 30%. If the average area under ragi is taken as about 2.5 million acres then there is ample scope for increasing the area under groundnut by at least 200 per cent. more. If the area extends to about 800,000 acres and the average yield raised to about 1,200 lbs. of pods per acre this crop alone will bring to the hands of the Mysore ryot a sum of over 2 crores of rupees and in addition, provide a large quantity of nutritious feed and fodder for his animals besides enriching the soil for growing other crops.

There are two main types of groundnut grown as field crops. The spreading varieties take a longer time to mature and require early sowing in April to June. They produce larger crops but require a large number of people to dig and pick the crop. Erect or tufted varieties produce all the nuts at the base of the plant in a bunch and it is very easy to lift the crop requiring less labour. They are mostly short duration varieties and require to be sown during the monsoon like other dry crops. They are admirably suited for growing under irrigation in summer. As a dry crop, the tufted varieties give less than 50% of the yield of the spreading varieties. If the monsoon is successful and the rains are well distributed they produce good yields. Spanish and small Japan varieties contain more oil than the old spreading varieties of Mauritius such as Big Japan or Virginia. The oil mills therefore demand the seeds of these erect varieties but the ryot will not be the gainer by growing them as they are low yielders. In the northern part of the State only early varieties can be grown and any improvement in yield of oil content should be combined with the early habit of growth.

Various experiments conducted on the Hebbal Farm

show that it is better to shell the pods and dry the seeds in sun for four or five days before sowing. If the seeds are soaked in water for a couple of hours and heaped in a warm corner of the house they begin to germinate in 24 to 36 hours. By sowing only the germinated seeds quick germination and a full stand are obtained. Sowing in lines allows space for weeding and cultivation. In all our experiments close planting has given the highest yields, the optimum distance being about 6 inches either way. Flowering of all varieties begins in about five weeks after sowing and lasts for about four weeks. If that period is moist and cloudy the largest number of pods are produced. On the other hand if the weather is dry, few pods are produced and the plants make only a leafy growth. When the late rains set in many pods are produced which do not ripen before the cold dry weather sets in, resulting in a large percentage of hollow or empty pods. Soils which are poor in lime produce thin shells and poor crops. A dressing of lime improves the yield, increases the thickness of the shell and therefore reduces the percentage of seed to the pod both in weight and in volume. The mills are disappointed if the percentage of seed to pod is low. Here again there is a conflict between the trade and the interests of the ryot. It is possible to fix up a standard for a healthy crop of every commercial variety and remove this obstacle in the way of introduction of improved methods in cultivation and manuring. The erect varieties are highly susceptible to the leaf spot disease known as 'ticca' which sometimes causes heavy damage. The dark green tufted varieties resist this disease to a great extent and in due course when they displace the old types, there will be no cause for anxiety. As good prices for groundnut depend upon a low percentage of the free fatty acid every attempt should be made by the trader to store the pods dry and keep down the perecentage of free fatty acids to about 5% in the kernels.

In order to secure the most desirable varieties to suit different conditions of soil and climate in the State a large number of varieties have been collected and tested for their yield and quality. From 1913 to 1927 there were twelve varieties

but at present there are seventeen spreading varieties and twelve erect varieties on the Hebbal Farm. They represent the most important commercial types from the well-known groundnut exporting countries in the world. Among the spreading types, *Senegal, Mauritius, Refisque, Barbados* and *Bassi* varieties have given over 30 to 40 per cent. more yield than the local *Sogatur* variety. Considering the labour required in harvesting, the low percentage of oil and the longer duration of the crop, attention is diverted more towards the improvement of erect varieties. The hardiness of the spreading varieties, the size of the pod and the larger number of seeds contained in them are qualities which are useful and they are being combined with erect varieties. Out of the erect varieties, *Valencia, Small Japan, Spanish, Tennessee white, Bunch Virginia* and *African white* are promising. The last two are very hardy but they are late maturing. *Tennessee white* has the biggest pod with a large number of seeds often numbering seven, but it is late and poor in oil. *Small Japan* and *Spanish* have seeds rich in oil often having over 50% oil in seeds. But they are very much attacked by the leaf-spot disease. The pods are small and a greater weight is sold by the ryot to the mill for a unit volume. This again is a disadvantage to the ryot. Selling by weight with safeguard against adding water seems to be a desirable practice. The red colour of *Small Japan* is a drawback as the international market does not encourage coloured seed. Spanish seed has a good cream colour and possesses 50% oil and is a highly desirable commodity for the market. Further improvement lies in producing strains with these qualities combined with greater productiveness and resistance to disease and drought. Fortunately in Mysore there is no serious insect pest at present.

A very large number of plant selections were made in all the varieties. An uniformity in the appearance of the pods and size was attained but there was no improvement in the production. Selection of pods varying in the number of seeds in each pod from one to four was made for improving the size of pods and a number of seeds. Experiments

were continued for over ten generations. It was not possible to fix the character for size or number of seeds. Continued selection seems to be necessary to keep up good size and larger number of seeds. By judicious screening of pods through standard sieves it may be possible to remove low grade pods for sowing and also put on the market a standard quality for each variety. Such a practice, if rigorously observed, will create a good reputation for Mysore nuts.

In the course of varietal tests a natural cross between *Spanish* and *Big Japan* was observed. Out of the three plants raised from it, one was erect, two were semi-erect and the fourth was spreading. On further selfing these plants the erect one has established a pure strain of erect plants with big pods of commercial size having many seeds like *Big Japan*. On further plot tests it was found to yield nearly as well as spreading varieties and very much more than the *Spanish* or *Small Japan* varieties. It was however a medium variety taking a fortnight more to ripen than the early maturing varieties now largely grown in the State. It branches freely and possessing a dark green healthy leaf is highly resistant to the leaf-spot disease. As a summer crop on the Irwin Canal Farm this strain which is well known as H.G.1, has produced more than 40 *pallas* (4,000 lbs.) of pods and many ryots have secured over 25 *pallas* (2,500 lbs.) in their plots. The pods of this strain have all the commercial qualities required by the trade. It is now being very widely distributed. Grown either as an irrigated crop or as a dry crop, H.G. 1 has a total oil content of about 48% against 46% of *Spanish* or *Valencia* varieties. Under pressure of about 300 atmospheres H.G.1 has yielded 37% of oil against 31% and 35% of oil in *Spanish* and *Valencia* varieties respectively. The quality of *Small Japan* is very similar to that of *Spanish*. H.G. 1 and *Valencia* have however thick husks thereby giving about 5% to 8% of less seed by volume than *Spanish*. By weight the difference is only about 4% to 6%. If the prices are settled on total oil and kernel weight, the trade will be helping the ryot to grow a high grade variety. H.G.1 is now spreading in some

districts of Madras. It is grown in Hyderabad also to some extent and is also being tested in the Punjab.

With a view to combining the desirable qualities of the bunch and the spreading varieties, a large number of crosses between various varieties were made in 1922. Since the plant flowers above the ground and the fertilised ovary turns down into the moist soil and develops into a pod there, there were great difficulties in evolving methods of hybridization. They were perfected in 1921 and utilised fully in continuing intensive breeding work between 1922 and 1928. In the first instance crosses between *Small Japan* × *Virginia* produced many interesting segregates in the F_2 generation giving scope for making 200 selections. The giant form of H.G.2 and many pigmy forms of small seeded varieties were evolved. Later on more than thirty to forty combinations were made. The interesting results obtained were incorporated in the thesis submitted by the writer to the University of Cambridge as part-work for his Doctorate degree. But of over a thousand segregates selected for observation there are now nearly 320 segregates under observation. Sixty-eight of them have given over 500 lbs. of pods per acre. Nearly ten of the segregates have yielded over 1,000 lbs. of pods to the acre. They vary mainly in habit of growth, colour of leaf, size and quality of pods and seeds, colour of seed coat, hairiness of stem and leaf, and resistance to drought and disease. They require to be multiplied and tested where irrigation facilities exist. The collection of varieties and segregates form a good foundation stock for further investigations and afford valuable material for other workers in groundnut.

In Mysore, groundnut has now become the most important commercial crop which brings in money, improves the soil and affords a source of good and cheap nutritious food for man and feed for cattle. A system of standardising and marketing the nuts has become quite urgent. The recommendations of the Groundnut Committee held at Bombay in September 1937, require to be modified and adapted to suit

Mysore conditions in order to enhance the value and reputation of Mysore nuts.

Classification suggested is as follows:—

Standard Types.—(Decorticated groundnuts.)

(*a*) *Khandesh*—Small round kernels weighing not more than 37 grammes per 100. This applies to *Spanish* and *Small Japan* types grown in Chitaldrug.

(*b*) *Coromandal*—Medium long kernels weighing more than 35 grammes but less than 50 grammes per 100. All the spreading varieties and H.G.1 belong to this type.

(*c*) *Bold*—Large long kernels weighing not less than 48 grammes per 100. H.G.2 and many new segregates come under this class. In all, the weight of 100 largest kernels should not exceed the weight of 100 smallest by more than 10 grammes.

Samples should have about 48% oil and not contain more than 5% of red seeds. The amount of moisture after drying in the sun for one hour should be fixed at about 5–6%. Foreign matter and dirt permissible is 4%. Damaged kernels allowed is 2%. Allowances of 25% for split kernels and 10% for broken kernels are made. We have to grow good nuts and market them in a condition which would stimulate a steady good demand.

(*To be continued.*)

SELECTIONS

Causes of Seed Failure

What are the chief causes of failure? We can name at least six possible causes very prevalent in Jamaica:—

1. Ravages of insects: Ants appear to be responsible for a large percentage of failures as they can be very voracious when they discover any seeds to their liking. Ample protection should be provided.

2. Sowing delicate seeds too deeply. A safe rule lays it down that small seeds may be covered to a depth equal to their width.

3. Excessive watering: Many people hold the mistaken idea that soil in which seeds are sown should always be kept well soaked. Such conditions cause some seeds to rot and encourage the "Damping Off" fungus, which is very destructive to young seedlings.

4. Extremes of light or shade: Seed boxes may be covered with old newspaper until the seedlings begin to peep out, after which they should be exposed gradually to strong sunlight.

5. Sowing at an unsuitable time or in improperly prepared ground.

6. Soil conditions are sometimes unfavourable to germination, causing only a small percentage of seedlings to come up.

—*The Journal of the Jamaica Agricultural Society,*
Vol. XLI, Nos. 7 & 8.

Pollination of Coffee

How many bees would be necessary for the proper pollination of 250 acres of coffee?

To care for the pollination of coffee trees on 250 acres would require some bees. Coffee blooms for three days, then possibly another flush of bloom within a couple of months if the first one did not set well. The amount of nectar gathered from coffee is small for the short blooming time will not allow much to be had. The trees are shaded with various others like Guma, Guava and Mocha, and the honey comes from them. The amount of nectar available from these shading trees determines the number of colonies that may be kept per acre, and not the coffee trees.

Just for the pollination of coffee, one could hardly have too many bees, as there are thousands of blooms to a tree or shrub, and as a rule they yield plentifully. However, when the coffee bloom is over, the extra colonies will starve. In Porto Rico, I did not receive more than an average of 60 to 75 pounds in one location from an apiary of 200 colonies. In a hilly country where coffee is usually grown, the bees do not fly so far. If the winds are heavy, as they are in Porto Rico, this also cuts down the distance of flight.

—*American Bee Journal,* July 1937.

Sugarcane Patented

A new sugarcane has formed the subject of a recent patent in the United States of America. It is the first occasion in which the protection of a sugarcane variety has been sought by the process of patenting it and it has been rendered possible by the passing of the Plant Patent Act of 1930 in that country. Under that Act some 150 patents have already been granted.

The protection of new varieties and races of plants has been subject of much discussion in recent years, but in America only has the matter been carried to legislative conclusion. The objective is clear. Private or commercial enterprise produces with, perhaps, much labour, a new and valuable variety of plant, and, in the natural course, looks for some material recompense for that labour. But, as soon as that variety is marketed, it can be taken up by rival dealers, and, in the course of very few years, competitive supplies reduce the price to that of the older and established varieties. The reward, therefore, must be sought in the first year or two or foregone. Nor is that the only drawback to the absence of protection. The need for a quick return forces commercial effort to attempt the constant supply of new varieties, the claims of many of which are extremely doubtful but suffice for catalogue purposes.

—*The South African Sugar Journal,* Vol. 21, No. 7.

Artificial Fecundation of Live-stock

Towards the end of 1936, a scheme of collaboration between the U.S.A. Department of Agriculture and the Argentine Ministry of Agriculture was drawn up for the purpose of carrying out a series of trials for the artificial fecundation of live-stock. The principal characteristic of these experiments consists in preserving the animal sperm obtained by Dr. Fred. W. Miller at the U.S. Animal Husbandry

Experiment Farm, Beltsville (Maryland), alive up to the time of its utilization in the fecundation of the Argentine herds. In order to contribute towards the successful issue of these experiments, the Pan-American Airways System has placed its regular aeroplane service, operating between Argentina and the United States, at the disposal of the authorities, free of charge.

It is generally known that one of the fundamental characteristics of artificial fecundation is the prolongation of the vitality of the spermatozoids, in order to facilitate their transport over considerable distances. Towards the middle of 1936, certain experiments were carried out between Great Britain and Poland on sheep, and on this occasion, it was possible to keep the sperm alive for two days. The present experiments of Dr. Miller relate to cattle; in recent trials, it was found that the sperm maintained a good vitality for a period of 15 days.

Research workers have already been studying this question for over a century, with a view to obtaining an improved system of cross-breeding, a fuller utilization of the services of pedigree breeding animals and a decreased sterility in the female animals.

—*International Review of Agriculture*, Vol. XXVIII, No. 9.

Effect of Pasteurization on Nutritive Qualities of Milk

The Annual Report for 1936 of the National Institute of Research in Dairying, University of Reading, recently issued, contains summaries of two researches carried out at the Institute upon the effect of pasteurization upon the nutritive qualities of milk. In one experiment, shorthorn bull calves when 4–5 days old were grouped in pairs of similar age and weight, and one of each pair, chosen by lot, received raw, and the other pasteurized milk until the completion of the experiment twenty-six weeks later. The milk diet was supplemented from the ninth week onwards with a little hay, and from the seventeenth week with a small allowance of crushed oats and flaked maize. Records were kept of the food consumed, the live-weight gains, general appearance of the animals and other relevant matters. Eleven pairs completed the experiment, and no material difference could be detected between the two groups. The average daily live-weight gain per head for the calves receiving raw milk were 1.967 lb., for those receiving pasteurized milk 1.969 lb. Another study was on the effect of commercial pasteurization upon the nutritive value of milk. The raw and pasteurized milks were from the same bulk, the experiments being carried out on rats. No marked loss in the value of milk as food which could

be attributed to commercial pasteurization could be detected. One-fifth of the vitamin C content of raw milk is lost in the course of commercial pasteurization, but this is partly due to exposure to light. Milk exposed in a bottle in the sun for half-an-hour loses half its original anti-scorbutic properties.—(*Nature,* Vol. CXL, No. 3533, pp. 115–16, 1937.)

—*Tropical Agriculture,* Vol. XV, No. 2.

Experiments on Manuring Rice in Bombay

1. *Time and Quantity of application of Sulphate of Ammonia.*— Two quantities (40 lb. and 60 lb. nitrogen per acre as sulphate of ammonia) applied in three doses were compared against a control on one guntha plots in five blocks with the following results:—

Mean Results of five Replications

Treatment	Yield per acre in lbs.		Increase per lb. of nitrogen		Per cent. increase over control	
	Grain	Straw	Grain	Straw	Grain	Straw
....	2,193	1,742	..	..	..	..
40 lb. Nitrogen in one dose ..	3,709	3,511	38	44	69	101
40 ,, ,, ,, two doses ..	3,480	2,736	32	25	59	57
40 ,, ,, ,, three doses ..	3,581	2,991	35	31	63	71
60 ,, ,, ,, one dose ..	3,870	3,758	28	34	76	115
60 ,, ,, ,, two doses ..	3,959	3,516	29	29	80	101
60 ,, ,, ,, three doses ..	3,919	3,451	29	28	79	89

These results bring out that:—

(1) Application of sulphate of ammonia has increased the yield of both grain and straw over no manure significantly, the increase being 69 and 80 per cent. with 40 lb. N. and 60 lb. N.

(2) The margin of profit, however, with 60 lb. N. is not greater than with 40 lb. N. The return of grain per lb. of nitrogen in the case of 40 lb. nitrogen-application was 38 lb., while it was only 29 lb. in the case of 60 lb. nitrogen. The three years' results are corroborative of the

finding that 40 lb. nitrogen as sulphate of ammonia is the most profitable dose for rice in tracts represented by Karjat.

(3) The effect of applying the same quantity of nitrogen in one or more doses has been in favour of applying the whole quantity in one dose. This is to a certain extent contrary to the results of last year when the yield with one or more doses was more or less the same.

2. *Pot Experiments with Oil-cake Manuring.*—Four oil-cakes, karanj, castor, groundnut and safflower were compared with sulphate of ammonia, all on the basis of 60 lb. N. per acre replicated five times in pots with six plants in each. Of the four cakes none was found to be superior to sulphate of ammonia in increasing the yield of grain. Castor cake was significantly superior to no manure and slightly better than the other three cakes.

Application of the oil-cakes in two equal doses has been harmful. The effects of the second dose prolongs the period of vegetative growth which gives out late tillers which remain green when the crop should be normally ready for harvest.

A combination of 50 lb. of nitrogen in the form of karanj cake and 10 lb. N. in the form of sulphate of ammonia has given significantly higher yield over 60 lb. N. applied as cake alone and almost as much as with sulphate of ammonia alone. The result is a hopeful one.

—Annual Report of the Department of Agriculture in Bombay Presidency for 1934–35.

Disease-Resistant Varieties of Crops

There is striking evidence that varieties of certain plants are able to withstand attacks of diseases like smut, rust, mildew, and wilts of various sorts, while other varieties are readily susceptible. The reason why certain varieties are resistant and others susceptible affords an extremely complicated study, but progress in finding out just what disease resistance is, has been made in several places.

Resistance may be due to several things. It may be due to the structure of the plant, both internal and external structure. It may be due to a heritable factor. Ordinarily this factor may be transferred and the plant breeder bases much of his work on the ability to transfer disease resistance from one variety to another. A third explanation of resistance is based on the physiological action within a plant. This may be due to the development of the tannin content of a plant, its acidity, its osmotic pressure and similar factors.

Time of Planting

Other escapes may be due to the fact that the plant is so early that it is harvested before the disease develops. Later varieties may be readily attacked. Many commercially important varieties have this factor of either earliness or lateness which help them to resist disease.

There are many peculiar external types of growth about plants which help them to fight off disease. For example, we have some varieties which have extremely hairy leaves; others have waxy leaves; others have thick leaves; etc. One of the most recent contributions to the resistance of wheat varieties to rust attributes this faculty to the small stomata in certain verieties. These small breathing pores in some cases keep out spores of fungi or disease which must enter through them. In other cases, the time of stomata opening appears to be of importance, according to recent work. This type of resistance is not only important from the plant-disease standpoint, but also from the standpoint of insect damage. Hairiness of the leaves may stop aphids. Various colours of leaves and parts of the plant also may have an effect upon their attraction or repelling action on various parasites.

Internal Structure

In some cases plants resist disease by means of some internal structure. The disease enters the plant but there appears to be an antagonism set up and the plant overcomes the disease organism. This may be due to the release of acids or poisonous substances through the action of enzymes. Recent work in Canada has shown that this may be an important factor in warding off black stem rust of wheat. With stinking smut or bunt, which has done so much damage to our wheat crop, it is thought by some workers that the organism enters all varieties and is overcome by some internal condition in those that are resistant.

The environment appears to have a great effect upon a plant's ability to remain healthy. Under some conditions of temperature and moisture the plant is very susceptible while under other conditions it is resistant.

Fertilizers Important

Fertilizers appear to play an important role. Potash has long been credited with building up a resistance to disease in plants, and there are many examples where this important element not only affects yields but reduces disease. Under some conditions plants develop considerable crude fiber and this stops some organisms from tearing down the plants. In many cases seedlings are susceptible to disease while the mature plants are resistant.

In the development of disease-resistant varieties, perhaps as much work has been done with black stem rust of wheat as with any other single organism and plant. Many outstanding varieties have been developed, but the situation is somewhat complicated by forms of the disease which differ in their ability to attack varieties. In other words, varieties are resistant to some forms of the disease and not to others. Inasmuch as there are about 100 known forms, one can readily see that the problem is no easy one. It is fortunate, however, that certain varieties are resistant to large groups of these forms, and so the possibilities of combining resistance to all forms in one variety is still great. Varieties of various crops resistant to leaf rust, crown rust, and many of the other types of rusts, including rust on ornamentals such as snapdragons, have been found.

It is very difficult to name high yielding varieties of a crop which are entirely resistant to all forms of any one disease and under all environmental conditions. There are many so-called resistant varieties, however, which are superior to most other varieties of the same crop. They are not only of value to the grower but also to the breeder who is interested in further development of disease-resistant varieties.

—*Better Crops with Plant Food,* July–August, 1935.

The Principles Underlying Spraying for the Control of Plant Disease

BY

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Spraying for the prevention or control of plant diseases is a relatively expensive practice. It should only be undertaken when other methods of control, such as the improvement of agricultural conditions, improvement of drainage and general sanitation or the adoption of a suitable crop rotation, are not likely to provide the satisfactory control of a disease. Again, the loss of crop or the extent of damage caused by a disease must be sufficiently great to warrant the expenditure on spraying. An exception to this might be made in gardens where the disfigurement of plants by fungus diseases may only affect their æsthetic value.

In tropical countries like Ceylon, where the temperature is always suitable for the development of fungi, humidity is often the main factor governing the incidence and spread of plant diseases. In consequence, in some parts of the Island it is necessary to spray regularly for the satisfactory control of many of our diseases. This fact should be appreciated before a spraying programme is undertaken since

money spent on spraying is largely wasted unless the spraying is conscientiously done and repeated when required.

The function of a fungicidal spray is either to kill the fungus concerned or to prevent the attack by a protective action. According to their mode of action, it is thus possible to divide fungicidal sprays into two groups—direct and protective.

Direct Fungicidal Sprays

Direct or eradicative fungicidal sprays kill through contact with the fungus on the plant surface. Such sprays are unfortunately of limited application since they can be used only against diseases in which the fungus is mainly on the *outside* of the plant. Diseases which come into this class are few, the chief being the powdery mildews, such as that which is common on orange trees. In spraying against these diseases, appearance on the plants and to continue to spray only so long as the fungus causing the disease is alive and active.

Protective Fungicidal Sprays

The principle of a protective fungicidal spray is to deposit on the plant a film or layer of fungicide so that when the spores or seeds of the parasite fall on the surface of the plant they are killed before they can penetrate the plant cells and set up disease. It is obvious that protective sprays must be applied before the fungal infection is established or they are useless. Once a fungus has penetrated *into* the plant tissues no amount of fungicide deposited on the surface of the plant will cure the disease and consequently the excision or removal of diseased tissue should precede the inauguration of a spraying programme.

To provide complete protection, the film or layer of fungicide must be complete. Every part of the plant liable to infection must be covered. In spraying to control a leaf-disease, for example, the upper and lower surfaces of every leaf should be sprayed completely.

A well-prepared and well-applied fungicidal spray will give a protective film on the surface of plants which will last for a considerable time. In plants where growth is continually taking place, spraying must be repeated at frequent intervals in order to ensure the protection of developing tissues. But it should be remembered that in these repeated sprayings it is necessary to spray only the developing tissues; the protective film will persist on the mature tissues. The intervals at which plants must be sprayed will depend not only on the suitability of the weather conditions for the spread of the disease but also on the manner in which the plant sprayed produces new growth. If new growth occurs at frequent intervals, as when trees put on new bursts of foliage, the spraying need only be repeated as

and when new shoots are developing and be continued until the new leaves have completed their development. (This applies, of course, only when the disease to be controlled is one affecting the leaves.)

Points to be Remembered in Spraying

When applying the *direct* fungicidal sprays an endeavour should be made to wet thoroughly every part of the plant on which the fungus is observed. The fungicide must come into intimate contact with the fungus or it cannot kill it. The spray in this instance must therefore be in the nature of a drench and may be delivered from a coarse nozzle. In this respect its application differs from that of protective sprays.

Protective fungicidal sprays must be applied in the form of a fine mist. A fine mist of spray is obtained partly by the use of a suitable nozzle and partly by delivering the spray through a nozzle at a high pressure. In a fine mist of spray the fungicide is dispersed into minute drops and the deposit of fungicide on the surface of the plant is more complete than with coarser sprays. The waste of spray is less when a fine mist is used. The ideal to aim at is to cover the plant with fungicide to such an extent that it just does not drip from the leaves. In practice, it will be found that it is best to spray until drops begin to fall from some of the leaves. The density of the fungicidal deposit is less when so much spray is applied that it drips from the plants than when it just does not drip. Excessive protective spraying is therefore not only wasteful but it is also less satisfactory than proper spraying.

Spraying should not be undertaken when plants are wet with rain or dew. The present dilutes the spray fluid or prevents it from coming into contact with the surface and thus makes it less effective. Once the spray has dried on the plants rain will not wash it off to any great extent, provided that it has been properly prepared and applied.

Some sprays are inclined to scorch foliage if they are applied in bright sunshine. Spraying should therefore be undertaken if possible in the early morning, after the dew has dried, or in the late afternoon or on a dull cloudy day.

Spraying should not be done in a high wind if it can be avoided. If not, advantage should be taken of minor wind currents to see that both sides of the plants or trees receive sufficient spray.

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The Preparation, Sowing and Care of Cigarette Tobacco Seed Beds

It is of the utmost importance that proper care should be taken of seed beds, in order to produce a successful crop of tobacco. No detail should be overlooked and no operation imperfectly done in raising the young plants to the planting out stage. For the successful growing of a uniform crop of tobacco, every endeavour should be made to obtain uniformity in size and strength of the seedlings to be transplanted. The site selected should be well-drained land, close to a permanent supply of water. The same site should not be used continuously as this encourages diseases and pests. The site should be away from big trees which have extensive root systems and too much shade. And eastern or north-eastern exposure is best, as the early morning sunshine is very desirable for the plants.

The seed beds should have an abundance of available plant food at the time the seed germinates and a sufficient supply to maintain steady growth of the seedlings during the period they remain in the beds. First of all, the site should be cleared of weeds and rubbish. The area cleared should be in excess of the actual area required for nurseries. Then the land should be ploughed once about a month before the actual nursery operations begin. After the first ploughing, a fairly heavy dressing of well-rotted farmyard manure should be broadcasted evenly and the area ploughed again sometime before the final operations commence. After this the site should be well levelled and eventually lined off into beds with broad shallow drains between the beds to serve as pathways. Fairly deep open drains should also be cut around the four sides of the site.

It is found very convenient to carry on operations and handle plants in beds of the following dimensions: 5 feet wide, 50 feet long with a shallow drain 3 feet wide between the beds.

On opening the pathways between the beds the top-soil should be thrown on the beds. Each bed should then be brought into fine tilth and properly levelled prior to being sterilized. If the soil is too dry it is essential to water the beds and then work the soil into a fine tilth with weeding forks.

The beds should be well sterilized to a depth of 3 inches by the open fire method. This will destroy the seeds of weeds and also kill the destructive organisms inhabiting the soil. The burning should be done when there is no wind blowing, so that full benefit may be derived from the heat generated by the burning material. The beds are well sterilized by burning maize stumps, sunnhemp stumps or brushwood and coconut husks placed in sufficient quantities to sterilize the soil to a depth of about 3 inches. Tobacco stalks should, on no account,

be used for sterilizing beds mainly for two reasons, (1) diseased portions of leaves may be left about on the site and a fresh infection of disease may result; and (2) when tobacco stalks are burnt an excess of potash is produced which is detrimental to the germination of seed. When the beds are properly sterilized the soil will be of light brick-red colour and will be very friable and easily pulverized. To clear any doubts as to the depth to which the soil has been sterilized by the fire, a very simple test can be made by burying a potato about 3 inches below the surface of the soil in the seed bed before burning and if the potato has been well cooked and the skin peels easily, then the soil has been sterilized.

After the beds have cooled a fertilizer mixture made up of ½ lb. of nitrate of soda, ½ lb. of sulphate of potash and 1 lb. of superphosphate is spread over each ten square yards of seed bed. This should be lightly dug in taking care not to bring to the surface any unsterilized sub-soil, the fertilizers and residual ash being thoroughly mixed with the surface soil. The seed beds are now reduced to a fine tilth and properly levelled with a hand rake. Now the beds are ready for sowing. Most growers still make the mistake of sowing their beds too thickly. Such beds produce delicate and tall plants unsuitable for transplanting. Good and healthy seedlings will be obtained when an ounce of properly cleaned seed is sown in an area of 100 square yards, which should produce enough transplants for 5 acres of field. To secure even distribution of the seed, it should be mixed with sand, a teaspoonful of seed being used for every quart of sand. Sow the seed very carefully, gently press the seed into the soil with the open palm, and water the beds lightly with a can fitted with a fine perforated rose. The seed beds should be roofed over with movable cadjans supported on a frame of sticks driven into the ground and tied together. These roofs should be about 5 feet high to allow the watering, weeding and spraying being easily carried out.

To obtain a uniform germination of seed, the beds should be watered regularly during the early mornings and late in the afternoons. The beds should be kept moist but not wet.

According to the area to be transplanted and the size of the flue barn and owing to the uncertainty of weather conditions, sowing of seed should be done in two or three sowings at an interval of ten or fifteen days. The beds should be covered during the night with cheap muslin cloth to keep off insects. The beds should also be kept free from weeds.

In order to guard against pests and diseases the beds should be sprayed weekly when the leaves of seedlings have attained the size of one's finger nail with the following mixtures recommended by the

Mycological and Entomological Divisions of the Department of Agriculture (Ceylon) :—

First two sprayings: ¼ oz. lead arsenate, 1 oz. bouisol colloidal copper, ⅛ oz. agral in one gallon of water.

When the plants are fairly big the following mixture may be used: ½ oz. lead arsenate, 1 oz. bouisol colloidal copper, ⅛ oz. agral in one gallon of water.

The spraying should be continued up to the time of transplanting. During the early stages of growth of the seedlings, the cadjan roof should remain over the beds all day.

The hardening of plants commence when the plants are about half-an-inch in height. When the plants come to this height, remove the covers daily during the morning for a few hours, increasing the daily period of exposure until the plants have hardened sufficiently to be left open all day long with no bad effects. Care should be taken not to expose the plants to heavy rains. Plants are ready for transplanting in six to eight weeks. The best way to test if a plant is fit for transplanting is by bending it; if it breaks with a snap then the plant is suitable for transplanting. Before pulling the plants, water the beds thoroughly and pull plant by plant taking care to pull only the strongest and the healthiest ones. Pack them carefully in baskets and despatch them to the field for transplanting.

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Soil Erosion: The Growth of the Desert in Africa and Elsewhere

It is a commonplace of geology that the surface of the earth is constantly in motion; that our mountain ranges have taken shape and our river courses and valleys have been excavated by rain, frost and wind. In many parts of the world this movement of the soil surface is taking place rapidly, with serious consequences to the agriculture of those countries, owing to soil erosion.

The soil is dependent for its stability on its normal covering of vegetation, but as a rule the soil proper is not more than 6 inches to a foot deep, and it is in the surface layer that the fertility resides. There is thus always a danger that if the cover of vegetation is removed, the soil itself may shift under the action of either wind or rain. The earliest cases of erosion caused by such movement of the soil are those which follow deforestation in regions where the mountains in which the rivers take their rise are below the permanent snow line, *e.g.*, in the eastern Mediterranean. There is no evidence in support of the belief that forests increase the rainfall of a country; indeed, by the

transpiration from their leaves, they must reduce the total amount of the rainfall retained by the soil, but they serve as its regulator; as the rain falls, it is absorbed by the spongy soil below the trees, rich in humus, and re-appears later in the springs and rivers when the rainy season is over. Too commonly, however, the forests have been cut down without regard to their regeneration, both for the value of their timber and for a desire to extend the grazing land.

The grazing animals themselves do further damage, especially if they are goats: not only do they destroy every seedling tree, but they tread hard paths down which the rain runs with gathering volume and increasing velocity, gradually forming gullies, until in a generation or two the hillsides get bared down to the hard, infertile subsoil. Nor does the damage end there. The rainfall, running off without a check, develops into a torrent and eats into the meadows bording on its course. The earth that has been torn away is carried down to the plains, where it is deposited, and turns the river into a chain of malarious swamps. Similar phenomena can be seen in the new countries opened up in the nineteenth century: forests were destroyed, and rivers have become subject to violent flooding.

Another form of soil erosion which is perhaps even more spectacular is that exhibited by the vast dust-storms, such as those which in 1934 swept over the United States east of the Mississipi. In Canada also wind erosion has occurred on a disastrous scale. The causes are easy to discern. This form of erosion occurs only in comparatively arid districts with an annual rainfall below 20 inches, and usually where the fundamental subsoil is of a sandy type. In America, before white settlement, these regions were covered with grass: some of the land was good grazing, with a fair depth of rich soil, but in the drier parts the sod was thin and there were only a few inches of soil. At first this poorer land was kept for grazing, but when the price of cereals rose rapidly from 1917 onwards, farmers began to extend to them the area under plough. The system of farming was of a wasteful type; the straw was burnt, no stock was kept, and very few years with no recuperative crop were enough to exhaust the limited stock of humus. When years of drought came, the light soil, no longer bound together by either vegetation or humus, began to drift in the fierce winds that sweep over those great plains. The plough had destroyed the binding power of the soil, and the whole of the fertile top layer was swept away.

The methods practised by the pioneers in the development of a new country are rarely those of sound agriculture, but merely a form of shifting cultivation. Many European soils have been cultivated for a thousand years or more without showing any decrease in production,

by the application has been maintained, perhaps, for four thousand years without soil erosion or loss of fertility.

In recent years where the danger of soil drifting is acute, means of cultivation have been introduced to minimize the risk. In some places the land has been divided into strips, bare land alternating with land under crop, in place of the former large areas under the same treatment. Incipient soil erosion through wind is in this way checked before it can proceed far. Another practice is to establish shelter belts to break the winds, though in some of the districts where wind erosion is worse—such as Saskatchewan and Alberta—it is no easy matter to find species that will stand up to the extremes of climate.

Erosion through wind, as described above, is worse on the flat plains, but erosion by rain is more common where the cultivated land is on a slope. In such parts the danger does not lie in a large annual rainfall, for that will, as a rule, generate a forest vegetation which protects the soil; it is the sudden heavy rainfall which causes most damage. Cultivated land on a slope may suffer from erosion by water of two kinds: (*a*) a continuous slow removal of the good soil (sheet erosion), and (*b*) a catastrophic wash-out (gullying). As preventive measures the slopes can be terraced and cultivated along the contours. The object of this is to enable the soil to absorb the rain as it falls without allowing it to set up a flow over the surface, but it may be necessary to break the terraces at intervals with spillways to lead accumulated water into drains or watercourses. Alternatively, belts of unploughed vegetation may be left to break a run-off. By such means, coupled with the growth of a leguminous plant which can be dug in to add nitrogen and humus to the soil, planters in tropical countries have been able to check erosion even where the rainfall is excessive. Such a system of contour terracing has been practised in China from time immemorial.

But wherever torrential rains occur there is always a danger of gullies being started in the bare soil. Gullying can be initiated either by careless methods of soil management or, on grassland, by over-grazing which bares the surface. In the early stages such gullying can be checked by throwing dams across the gash, made of anything that will hold up the rush of water and cause the sediment to accumulate. Even more effective has been the introduction of rapidly growing vegetation, *e.g.*, Kudzu (*Pueraria thunbergiana hirsuta*), a creeping leguminous plant which not only checks the flow of water and filters out the silt, but binds the earth and at the same time gathers nitrogen.

The examples of erosion hitherto described are those that are due to unthinking exploitation of the soil by civilized man. Consideration should also be given, however, to what is taking place in

Africa under native systems of farming. In the first place, it must be realized that, whereas European farming is essentially founded upon a rotation of crops, in which a recuperative leguminous crop finds a place and in which live-stock play their part in converting into manure those parts of the crops, such as straw, which are not valuable for human food, together with grass and other rough fodder, the African tribes, on the other hand, are for the most part still in the more primitive stage of "shifting cultivation". Under this practice the cultivator clears a plot of land, perhaps, burning off the timber, before putting in his food crops. After two or three years of continuous cultivation the soil begins to become exhausted, and when that takes place and weeds become intractable, the plot is abandoned and a new piece of land is taken up. The abandoned plot in course of time recovers sufficiently to be taken into cultivation again, but under this system a tribe requires several times as much land as is actually under cultivation at any one time.

Another point of great importance is that the Bantu tribes, which predominate in East Africa, attach the greatest value to cattle, which represent wealth and position, but serve little or no economic purpose. They are not eaten, except ceremonially; by many tribes they are not milked; they are not beasts of burden, and their dung is not used as manure. At the same time every native is anxious to increase the number he owns, for, on that depends his position in the tribe.

Within the past century, since British rule has maintained peace, the human population has increased very markedly, and this increase has been accompanied by an even greater increase in the numbers of live-stock. The animal population has far outstripped the means of sustenance and is destroying vegetation in uncultivated areas which ought to be recuperating in readiness to be brought into cultivation again. The Kenya Land Commission, reporting in 1923, stated that "Probably about the year 1920 the main stock areas of the natives reserves had attained their optimum carrying capacity, and although fully stocked were not over-stocked". Since that time the cattle population has roughly doubled itself. Through persistent over-grazing, the ground has been beaten hard into little paths, even where it has not been eaten bare, and thus large areas have been laid open to erosion from rain, especially on the hillsides. Under cultivation, the humus of the soil rapidly becomes exhausted; the climate produces recurrent periods of drought followed by rainfall of fierce intensity, with a result that soil erosion, widespread and disastrous, occurs. Furthermore, the native population not only practises a destructive and wasteful form of agriculture, but, as already mentioned, keeps a vast uneconomic herd of cattle, including the devastating goat in large numbers. It is small wonder that famine is never far away from some of the tribes, and if this is to be avoided the native must change his methods or

limit his numbers. African soil was never rich, the soil erosion has been developing for years without attracting much notice, but has now reached the stage where the growth of the desert may speed up catastrophically.

It is only recently that the dangers of erosion in Africa have been realised. The problem and the means of attacking it have, however, occupied increasingly prominent places in various Government reports since 1929, and it is now evident from Sir Frank Stockdale's report on his tour through Africa this year that all the African colonies have become erosion conscious.

Much yet remains to be done before the arrears of years of misuse of the soil can be repaired, and before the native population can be educated to systems of farming which will maintain the fertility of the land. Drastic changes in native custom will need to be brought about, and in many cases expenditure will be called for which can hardly be found within the limited resources of a particular colony.

The regeneration of wasted lands must begin with closing them for a time to grazing, so as to allow the return of natural vegetation. A certain amount of minor engineering is needed to check run-offs and *dongas* by dams and plantations. At the same time, cultivators must be taught the virtues of contour ploughing and planting and of vegetation strips in the cultivated land.

Such measures, however, do not touch the major causes of erosion, *i.e.*, over-stocking. To combat this, legislation is necessary with a view to compelling a reduction in the number of cattle. This must be done by way of purchase, and since the animals discarded would at first be practically valueless for food, factories would be required to turn the carcasses into fertilizer, and later, into successively better products as the quality of the cattle dealt with improved. A reduction in the number of cattle or sheep to one-half would not only relieve the pressure on the land, but would give the native owners some chance of improving the quality of their live-stock, both by selection and better feeding; whereas at present numbers only are valued. Education should also be the means of including the natives to use cattle economically for milk or meat and for traction, or at least to sell them for good. One cannot escape from the fact, however, that forcible limitation of the number of cattle a man may hold will be a grave interference not only with tribal custom, but also with the dignity of individuals. One idea which has its attractions is that a special token currency should be introduced for the purchase of native live-stock that would constitute a visible display of wealth and status.

Even more fundamental must be the education of the natives in the adoption of a conservative system of farming—a rotation that would include leguminous crops, and thus help the native dietary as

well as restore nitrogen to the soil. Already compost-making is another means of maintaining fertility that is being taught to the natives. The African cannot increase or even maintain his present numbers unless he learns how to use his plot of land so that it will continuously produce food. Demonstrations have shown how it can be done, but it will need both a strengthening of the agricultural staff and years of effort before the improved practices are taken up. Effort in all these directions on a large scale is an urgent necessity. Many of the tribes are on the verge of starvation, the desert is growing apace, and as the cropping or grazing area shrinks the pressure upon it becomes greater and destruction proceeds at a compound interest rate. Responsibility for action must lie not only on the Colonial Governments, but on the British Government itself, which has declared itself trustee for the native populations and must save them from themselves.

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The Cultivation of Pyrethrum in Japan

Through the courtesy of the Department of Overseas Trade the Imperial Institute was furnished a few years ago with a valuable report on the pyrethrum industry of Japan, which had been prepared by the British Vice-Consul at Seoul, Japan. It covered every aspect of the subject, including the methods of growing and preparing the flowers, details of the production and trade, and a discussion of the economics of the industry. The report was published in this *Bulletin,* 1930, **28**, 300–42, but owing to the great interest the report aroused the number went out of print. In view of the attention that is being given to the cultivation of pyrethrum in many parts of the Empire and the requests that are received from time to time at the Imperial Institute for information as to the methods practised in Japan, which is still by far the largest producer of the flowers, it has been thought desirable to reprint in the present issue those portions of the original report which are likely to be of most concern to the planter. The figures in the introductory section have been brought up-to-date from reports received periodically from the Department of Overseas Trade.

Introductory

So far as Japan is concerned Pyrethrum (Japanese: Jochugiku or Mushiyokegiku) is a product of recent years. Although there is some doubt regarding its earliest origins, it appears to have been known in Persia for its insecticidal properties several centuries ago. It was introduced into Europe early in the nineteenth century, when both the plant itself and powder ground from the flowers were imported

from the Persian fields and markets to meet a widespread demand for an effective vermin killer. Some forty or fifty years later, during the period 1850–60, another species of the plant was introduced from Dalmatia which proved more effective as an insecticide than the Persian species, and rapidly superseded it in the pyrethrum fields of Europe.

It was not until 1881, however, that pyrethrum was introduced into Japan, cultivation being first undertaken experimentally four years later with the Dalmatian species in Wakayama Prefecture, and with plants from American seeds sown at the farm of the Komaba Agricultural School in Tokyo. The success of these experiments suggested the commercial possibilities of the flower, and serious cultivation began in 1886.

Cultivation spread gradually, and in 1896 the plant found its way to Hokkaido, the northern island of Japan, in the form of twenty-five seedlings, brought from a Tokyo nursery by Seiichiro Keneko, a native of Niigata. Settling in the Ishikari District of Hokkaido, this enterprising farmer planted his handful of seedlings, and, finding the soil and climate favourable, began in 1902 to extend cultivation on an ambitious scale.

Since that date the area of land in Hokkaido and other prefectures given over to the cultivation of pyrethrum has steadily increased until to-day probably three-quarters of the world's yield is claimed by Japan.

Striking evidence of this increase is afforded by comparison of the yields for 1912 and 1926. During the fourteen years 1912–26 the area under cultivation in Hokkaido spread from approximately 31 acres to 25,600 acres and the yield from 14,000 lb. to 10,071,100 lb. During the next ten years the growth was on much the same scale, the total area in 1936 reaching 71,880 acres and the yield 25,000,000 lb. In 1937, however, the estimated area and yield showed a decline. The detailed figures for the different Prefectures are given in the following table:—

	1935		1936		1937	
	Area acres	Yield tons	Area acres	Yield tons	Area acres	Yield tons
Wakayama ..	3464	1,390	4,040	1,240	3,460	1,107
Okayama ..	3,084	1,060	2,930	870	2,500	812
Hiroshima ..	5,000	2,093	5,220	1,720	5,000	1,925
Yamaguchi ..	700	273	1,000	320	1,000	370
Ehime ..	4,470	1,618	4,140	1,240	4,140	1,110
Kagawa ..	2,928	1,164	2,800	857	2,060	738
Hokkaido ..	46,550	5,155	51,750	4,880	42,000	3,850
TOTAL ..	66,196	12,753	71,880	11,127	60,160	9,912

Description of the Plant

While for the sake of convenience the trade name of pyrethrum has been used throughout this report to designate the plant, which is a perennial of the Compositæ family, the most generally accepted botanical name of the Dalmatian species appears to be *Chrysanthemum cinerariæfolium*, Vis. (syn. *Pyrethrum cinerariæfolium* Trev.).

In general appearance not unlike an English wild camomile, this is the only species of the plant bearing white flowers.

The flowers of the other species, of which the Persian, Armenian, Hungarian, and Indian are the chief, are coloured rose-pink or red.

Among the red flowered plants the commonest are those of the Persian species, known to botanists as *Chrysanthemum coccineum* Willd. (syn. *Chrysanthemum roseum* Web. and Mohr, or *Pyrethrum roseum* Bieb.).

Apart from the colour of the ray-florets, the main superficial distinction of the Dalmatian species is the darker colour of the leaves and the presence of the fine hairs on their lower surface.

Advantages and Disadvantages of the Dalmatian (white) Species

The Dalmatian species (1) is an abundant seed producer with a good rate of propagation; (2) bears a large number of heads on each plant and accordingly yields large crops; (3) has large roots which are quick and sturdy growers; (4) is more delicate as regards resistance to disease and injury; (5) flowers too late to be used against early vermin; and (6) bears small florets.

Advantages and Disadvantages of the Persian (Red) Species

The Persian species (1) flowers early and thus yields early crops; (2) bears large florets which are convenient for industrial purposes; (3) has few heads on each plant and accordingly yields small crop; (4) produces few seeds and shoots, the rate of propagation being accordingly poor; and (5) retains poor colour in the manufactured powder and consequently commands only a low market price.

A comparison of the qualities of the red and white species reveals that the white is the more prolific seed and crop producer and retains a finer colour in the manufactured product. Its insecticidal action is also quicker. For these reasons the white-flowered plant has the monopoly of insecticide-plant cultivation in Hokkaido, the red-flowered plant being grown solely in gardens for decoration.

Pyrethrum Manufactures in Hokkaido

Owing to the traditional position of the Kobe District as the centre of the industrial and commercial side of the pyrethrum trade,

Hokkaido has been slow to develop the manufacture of pyrethrum powders and sprays, and the bulk of the pyrethrum crop leaves Hokkaido in the form of dried flowers.

An industrial concern, however, has been established at Kutchan under the name of the Hokushin Yakuso Kabushiki Kaisha.

What might be termed the three basic products are: (1) flower powders; (2) leaf and stalk powders; and (3) liquid extract mixtures.

(1) Into the first category fall those articles known to the trade as "Fly-powder", "Satchfun" (Insect-powder) and "Nankinsan" (Bug-powder).

These are no more than the dried flowers artificially desiccated and ground to powder by successive grinding machines until the required degrees of fineness are obtained, the powder being finally sorted by machine into different qualities according to the degree of fineness and packed for the market.

The powders are used for the extermination of flies, of noxious insects found on fruit-trees, vegetables, cattle and poultry, and also of bugs and fleas.

(2) Since powder ground from the stalks of pyrethrum has been found to possess insecticidal properties in certain forms and against certain insects, the Hokushin Yakuso Kabushiki Kaisha have devoted a large part of their activities to the manufacture of this powder.

The dried stalks and leaves are chopped by machines, artificially desiccated, pulverised in the grinding machines, and finally machine-sorted.

The powder thus obtained is either made into mosquito sticks for use in houses and poultry-runs, or mixed with the powder obtained from the dried flowers to form an insecticide for use as a grub-killer. The latter is widely used throughout Japan by local sanitary associations.

(3) The third basic product of the industry is Pyrethrum Extract, which is obtained by the following process:—

Pyrethrum powder ground from the dried flowers is wrapped in a cloth and placed in a tin filled with volatile oil. While being soaked, the bag should be shaken from time to time in the oil until two or three days have elapsed, when the bag is removed from the oil and the liquid drained from the bag. This process is repeated in a second tin of volatile oil, and the liquid thus obtained mixed with that obtained from the previous extraction.

By subsequent distillation the volatile oil is removed and the effective constituent is left. This is added to alcohol and water and thoroughly shaken into a creamy emulsion.

This extract in different degrees of dilution is sold for the extermination of bird-lice and vermin.

From the three basic products described above are obtained a number of derivative products, of which a brief description follows:—

Pyrethrum carbon mixtures.—A mixture of pyrethrum and carbon has been found particularly effective as a destroyer of the larvæ of the common white (cabbage) butterfly. It is prepared by mixing 1 part of the powdered pyrethrum flowers with 40 parts of charcoal, and is ready for use after it has been stored for two days in a sealed jar.

Pyrethrum lixivium.—This is obtained by distilling a mixture of pyrethrum powder and water in the proportion of ⅛ oz. to ¼ oz. powder to 3 pints of water. It is used chiefly to exterminate the larvæ of butterflies and moths.

Pyrethrum petroleum emulsion.—A mixture of pyrethrum powder and petroleum in the proportion of 2½ oz. of powder to 3 pints of petroleum is kept stoppered for at least two days, after which an emulsion is prepared by filtration in the same manner as petroleum emulsion is obtained. Pyrethrum Petroleum Emulsion is chiefly used for the protection of crops against blight.

Pyrethrum lixivium petroleum.—This is a more active exterminator of dust and dirt carriers than plain petroleum and takes the form of a solution made from pyrethrum powder and petroleum in the proportion of 2 oz. of powder to 3 pints of petroleum, the solution being firmly stoppered for at least two days and subsequently strained through a cloth.

Tincture of pyrethrum.—Tincture of pyrethrum is obtained by macerating pyrethrum powder with alcohol (in the proportion of about 1 oz. of powder to 1 lb. of alcohol) in a stoppered container for at least one week, and filtering the product. This insecticide is used mainly to exterminate the insects which attack cherry, peach and mulbery trees, and to eradicate lice and fleas from the hair of cattle and horses.

Pyrethrum powder.—The powder produced in Japan under this trade name is a mixture of 1 part of ordinary pyrethrum powder and 3 to 5 parts of powder of lime or starch, the mixture having been kept firmly stoppered for the space of one day before being ready for use. As an insecticidal agent, it is effective against the same insects as ordinary insect powder.

Mosquito sticks.—These joss-sticks are made by mixing carefully selected pyrethrum powder with a small quantity of pyrethrum stalk powder, stiffening the mixture with the glutinous powder of cinnamon

leaves, the latter being in the proportion of about 1½ to 2 per cent. of the former. As the name implies, these sticks are used for smoking out mosquitoes.

Climate and Soil Requirements

Pyrethrum thrives best in a comparatively dry climate and well-drained sandy soil. In fact, provided that the climate and soil are not damp, the plant will grow even on mountainous or waste land. When it is planted on sloping ground, however, a larger quantity of manure is required than on level ground, the manure in the former case being constantly washed down the slope.

In Persia and Dalmatia (Yugoslavia) the plant is usually cultivated on dry land at a high altitude, the Persian species in particular flourishing as high as six or seven thousand feet above sea-level. In Okayama, Hrioshima and Wakayama, the chief producing centres in the main island of Japan, the climate is comparatively dry and warm, and cultivation nowadays covers even the hillsides where the soil is of the right texture.

Hokkaido, though colder than the producing centres in the main island, enjoys the advantage of heavy snows in winter. Under their winter-long covering of snow the roots are protected from the cold, whereas in the main island the winters, though seldom bringing heavy falls of snow are sufficiently cold to freeze the surface of the land and thereby injure the roots of the plants.

Although the rainfall in the producing centres of Hokkaido is small during the period from growth of the flower to harvest, no actual drought is suffered on account of the atmospheric temperature which prevails in these parts.

Cultivation

(1) *Sowing.*—For seed-beds, land is chosen which is exposed to the sun and has soft, sandy soil and good drainage; this is ploughed deeply, the lumps of earth are well crushed and flat ridges are raised of a width of 3 feet. Well-choped stable litter is applied as manure and night-soil and superphosphate of lime are added. Excessive application of manure promotes too rapid a growth and care must, therefore, be taken to apply it in moderation. After the lapse of a week the land is ploughed again so as to mix the earth and manure, and pebbles and clods of earth are eliminated by sifting with a riddle having a half-inch mesh. The ground is then levelled and flattened with gentle and even pressure, by means of a wooden board or plate, so as to ensure even growth of shoots, and the seeds are sown in the proportion of about 2 pints of seed to 300 square yards of ground.

Seedlings from a given area of seed-bed cover on the average after transplanting an area ten times as large.

There are two sowing seasons, one in spring and the other in autumn. Spring sowing is carried on in the middle of May and autumn sowing towards the end of September. For spring sowing, seeds collected in the previous year are used, the seeds used for the autumn sowing being those collected during the current year. Old seeds should be avoided on account of their poor germination. The sowing season in Hokkaido is the spring.

Before being sown the seeds are placed in tubs of water and thoroughly soaked; they are then wrapped in cloth or sacking and buried in damp sand for four or five days, after which they are mixed with dry sand and sown evenly and in small quantities. Even sowing is usually ensured by the use of an empty tin can in the bottom of which holes have been drilled. Earth should then be sprinkled over the seeds by means of a riddle having a third of an inch mesh until the seeds are no longer visible. In order to protect them from becoming parched by the direct rays of the sun, the beds should be shaded with straw matting. They should also be protected from wind and drought by being fenced round with reed screens, which should only be removed at night or in cloudy weather. During prolonged spells of heat the beds should be watered regularly after sunset. A careful watch should be kept for weeds, which check growth or even destroy the shoots. If these directions are followed the shoots will appear in most cases in twelve or thirteen days. The straw shades may then be carefully removed, preferably on a cloudy day.

To promote vigorous growth, the seedlings, when grown to a height of 2 or 3 in. should be treated with fertiliser, the most suitable for the purpose being night-soil diluted with water in the proportion of 1 part of night-soil to 3 parts of water. By the end of September seedlings from the spring sowing may be expected to reach a height of 3 or 4, or, in good conditions even 5 in.

(2) *Transplantation.*—When the shoots have reached this stage, which if they are spring sown falls between the middle of September and the beginning of October, transplantation must be taken in hand. It is important that the right season be chosen, for if they are transplanted too early the flowers are poor, while if they are transplanted too late the cold will kill them before their roots have taken a firm hold.

As pyrethrum is a perennial and can be cultivated for several years, nothing can be done to the soil after the shoots have been planted. This must, therefore, be well prepared beforehand, the ground being ploughed, all weeds removed by the roots and the surface carefully levelled. When the farm has been suitably prepared, seedlings

are planted in lines at intervals of from 7 in. to 1 ft. between the plants and 1 ft. to 2 ft. between the lines. To prevent stagnant rain-water from gathering round the roots and thereby destroying the seedlings, it is advisable to plant them on raised ridges. The dykes thus formed between ridges drain away the water from the roots. To obtain good blossoms the plants should not be planted deeply, as in such a case only stalks and leaves would appear. It is usual to plant only one seedling in each place, but in the case of inferior seedlings two are sometimes planted together.

Cultivation of pyrethrum in Hokkaido begins with the sowing of the seeds in spring and the transplanting to farms in autumn of the seedlings grown from these seeds. No crop is expected in the following year, which is given over to weeding. In the second year, however, flowers can be picked, though in the Kamikawa District, which is the centre of cultivation in Hokkaido, the second year's crop rarely exceeds 33 lb. per acre.

As, therefore, the land may be said to yield no crop for another year, seedlings from the second year's sowing are laid aside in another bed and seedlings from the third year's sowing transplanted to the farm. Crops are thus yielded from the first year's seedlings after the transplanting of the third year's seedlings, and by these methods the ground is most economically used.

(3) *Dividing the roots.*—After the flowers have been gathered for three or four years the yield falls off appreciably. Old roots are then changed for young or are divided. For division active roots of this age are selected, and the divided portions planted separately. Compared with the seedling plants they are of poor growth, and the season in which their flowers can be picked is short.

(4) *Rotation of crops.*—As has already been stated, pyrethrum is a perennial. The flower yield, however, decreases after three or four harvests. It would consequently be advantageous to arrange a suitable rotation of crops, but experiments in Hokkaido to this end have unfortunately failed to produce satisfactory results, and the Hokkaido farmers have wisely decided to concentrate on one good crop rather than divide their attention between two or more indifferent ones.

(5) *Manures.*—In fertile soil excessive application of nitrogenous manures results in a profusion of leaves and an absence of flowers. The principal manure used in Hokkaido is stable litter, but a good auxiliary manure in the form of night-soil, plant ash, fish cake, or superphosphate of lime is also required.

The principal manure is used to prepare the farm for receiving the seedlings at transplantation, and auxiliary manures are applied in autumn after the flowers have been picked. In the latter case the

manure is put in the dykes formed by the ridges in which the plants are grown, and the manure itself covered with earth. This manure, if given in autumn, conserves nourishment for the plants through the winter for the following season, but if given in spring a harvest of leaves is reaped and no flowers.

In the Ishikari District about 1 ton of stable litter and 25 lb. each of fish cake and superphosphate of lime are generally used in a year for each ¼ acre of land under cultivation.

(6) *Weeding.*—Systematic weeding should be carried out three or four times a year, special attention being given to the dykes between the ridges.

It is important that the earth in these dykes should occasionally be turned and crushed in order to prevent the surface of the soil from becoming dry.

Picking

The plants should bear their first marketable crop in the third year after the seeds were sown. In the Kamikawa District the crops amount to some 130 lbs. per ¼ acre for the third year, 180 lbs. each for the fourth, fifth and sixth years, and 130 lbs. for the seventh year, after which the amount gradually decreases and ceases to be economical.

The chief object of cultivation being to obtain an insecticide, it is important that the season for picking should be when the insecticidal agent in the flowers is most potent. Although the flowers are in full bloom for seven or eight days, the best condition for picking for the purpose of insecticide is when the flower-heads are about 70 per cent. open. Picking should in no case be begun before the flower heads have partially opened, as in such an event not only would the yield be small but the flowers would be of inferior insecticidal value.

Experience has proved that to delay picking in the hope of obtaining a larger harvest has more often than not been rewarded by the partial or total destruction of the crop by the rains which usually fall about that time.

In fact the actual date of the picking season varies according to the state of the flower and the climatic conditions of the district in which it is produced. In the Ishikari District, for instance, there are as a rule three pickings, the first on July 3 or 4, the second on July 10, and the third on July 18. The pickers, carrying baskets about 15 in. in diameter and 8 in. deep, advance along the field drawing the stalk through their fingers so as to snap the flower-heads off at the neck and drop them into the baskets with one motion. It is claimed that girls can gather from 40 to 80 lbs. a day.

This method, while suitable for small farms, is not usually followed on the large ones, where the quicker method of gathering the flowers with their buds attached is the general rule. In the latter case noticeably backward flowers are left to be gathered some five or six days later.

In the Districts of Kamikawa and Kutchan, where the plant is cultivated on a large scale, the crops are gathered between July 5 and 10, when the flowers are considered to have reached the condition most suitable for gathering, by cutting the flowers from their stalks with a sickle and hackling. The disadvantages of this method are first that the flowers so gathered are liable to become soiled by the mud, and secondly that backward, suitably open, and overblown blossoms are indiscriminately mixed together to the detriment of the quality of the powder into which they are subsequently to be made.

Drying

The method of drying most widely practised is to spread the picked flower-heads thinly on straw mats and place in the sun, turning them from time to time so as to ensure even exposure. At night they are taken indoors, and on the following morning brought out and again exposed to the sun. The flowers picked each day are carefully kept in lots separate from those picked on previous and subsequent days. To prevent danger of mustiness and deterioration in quality which frequently accompanies this method of drying, reed mats laid on wooden boards are sometimes used instead of straw matting. Except in times of rain and storm, these can remain out of doors the entire time, and only require the cover of a roof at night to keep off dew; the flowers thus obtain uninterrupted benefit from the wind. By this method drying is completed in five to seven days.

Another method in common use in Hokkaido is to hang the flowers from a drying frame while the stalks and leaves are still attached.

The flowers are considered to be sufficiently dry when they can be crushed to powder by gentle pressure between the thumb and forefinger.

While Hokkaido drying is usually done in the sun, this method is less effective than drying in the shade, for the former method is naturally at a disadvantage in times of rain and storm.

For drying in the shade, sheds of a size suited to the requirements of the farm are erected in a place through which a good current of air passes, shelves are fitted in the shed and reed mats or straw matting spread on them. After they have been dried in the sun for a day, the flower-heads are spread thinly over the mats in the shed and turned once or twice in 24 hours. At the end of one or two

days of this process, when the flower-heads appear to be dry, they are gradually arranged in piles so as to complete the whole process of drying in about five days. This method is more convenient than drying by sun but is less widely used on account of the greater expense involved.

The most advanced method of drying is by artificial heat. Except for manufacturing on a large scale, however, this method is uneconomical owing to the costly apparatus which it requires.

Storage

Flowers must be thoroughly dried before storage, which should be effected in a dry place indoors. If insufficiently dried they will become mouldy and lose their insecticidal power.

Flowers which have been grown from sandy soil should be carefully sifted so as to eliminate all trace of sand. The flowers are packed into boxes, covered with paper and trodden or pressed down so as to fit as tightly as possible into the boxes, which are then closed and hermetically sealed. This method of packing for storage serves a dual purpose, moisture being excluded and economy of space secured.

Where the stalks and leaves are to be used, these when thoroughly dried, are made into bundles bound in two places and stood on end in as dry a place as possible. If they are stored in an airless or leaky place mould develops. Should this form on any part of the bundle it rapidly spreads to the whole and renders it useless for commercial purposes.

Packing

In Hokkaido, when the flowers are pronounced fully dried, they are brought in before 3 o'clock in the afternoon, and, if possible, packed on the following day. Formerly, the packing material consisted of straw bags which, with their contents, weighed some 64 lb. each. After being filled with dried flowers, these bags were encased in straw matting, which was finally stitched at the ends and securely tied with rope. These materials were gradually superseded by gunny bags, which accordingly became the standard packing material under the Inspection Regulations of 1927. Gunny bags must be unlined, but need not be new. They must be of good quality, measure 3 ft. 3 in. long by 2 ft. 4 in. wide, and weigh not less than 2½ lb. When the bags are fully packed, the mouths are securely sewn with strong string or cord. The cost of new gunny bags ranges from 24 to 30 sen apiece, but according to information advanced by the Agricultural Section of the Hokkaido Government Office, most of the gunny bags used for

packing are those in which the cheaper grades of rice have been imported from India and the Straits Settlements.

In the Kobe District, in order to effect economy in freight, pyrethrum for export is mechanically compressed. The flowers are packed in mat-rush so that each package weighs 112 lb. net, and four of these are assembled in a gunny bag and compressed into a single package, some 3 ft. 5 in. by 3 ft. 5 in. by 2 ft. 5 in. This is then bound round with steel bands and removed for export. There are five of these compressed packages to a ton.

The cost of packing by this method amounts to approximately Y 4.50 for each package, inclusive of the cost of material.

Cost of Production in Japan *

The actual expenses of production naturally vary with the condition of land, area under cultivation, methods of production and climate. For the purpose of illustration, therefore, it is simplest to take the figures furnished in respect of farms in the Kutchan District, which are operated under a partial contract system, and which are divided for the purpose of cultivation into areas of 50 chobu (about 120 acres) each. The figures follow:—

Cost of production over a period of five years
(per chobu about 2·45 acres)

	Yen	Remarks
1st Year—		
Seeds	7·50	2·5 sho (about 8 pints) at Y 3 per sho.
Cost of preparing beds, sowing and weeding	30·00	Sowing area, 1 tanbu (about ¼ acre). Wages of 20 women at Y 1·50 a day.
Cost of preparing main farm and transplanting	35·00	Wages for ploughing Y 12. ,, harrowing (twice) Y 4. ,, ridging, Y 2. ,, planting seedlings, Y12. ,, carrying plants, etc., Y 5.
TOTAL ..	Y 72·50	
2nd Year—		
Cost of weeding	47·00	Horse-weeder (twice) Y 7. Hand-weeder (4 times) Y 40.
Farm rent	30·00	
TOTAL ..	Y 77·00	

* The costs given in this section relate to conditions eight or nine years ago and may not hold good to-day. They will nevertheless serve as a guide to the relative costs of the different operations.

3rd Year—	Yen	Remarks
Cost of weeding	47·00	As in previous year.
Cost of fertilisers and fertilising	40·00	Herring-cake, soya-bean cake, superphosphate of lime.
Farm rent	30·00	
Cost of straw-mats ..	25·00	100 at Y 0·25.
Cost of straw rope ..	5·00	20 kan (about 165 lb.) Y 0·25 per kan (about 8·27 lb.).
Wages for hanging plants on frame ..	1·00	
Wages for cutting and drying ..	32·50	15 women at Y 1·50 5 men at Y 2·00.
Wages for packing ..	37·50	
Cost of gunny bags ..	7·00	20 at Y 0·30, the balance being accounted for by thread and needles.
TOTAL ..	Y 225·00	

4th Year—		
Cost of weeding	47·00	As in previous years.
Cost of fertiliser and fertilising	40·00	,, ,, year.
Farm rent	30·00	
Cost of additional straw-mats and rope	6·00	
Wages for hanging plants on drying frame	1·00	
Wages for picking	32·50	,, ,, ,,
Wages for packing	37·50	,, ,, ,,
Cost of gunny bags ..	7·00	,, ,, ,,
TOTAL ..	Y 201·00	

5th Year—		
Cost of weeding	47·00	As in previous years.
Cost of fertilisers and fertilising	50·00	,, ,,
Farm rent	30·00	,, ,,
Cost of additional straw-mats and rope	6·00	
Wages for hanging plants on drying frame	1·00	
Wages for picking	32·50	,, ,,
Wages for packing	37·50	,, ,,
Cost of gunny bags	7·00	,, ,,
TOTAL ..	Y 211·00	

On the assumption based on actual experience that only the third, fourth and fifth years yield crops, of which the average annual output per chobu is 150 kan (about 1,240 lb.), and that the average market price of the dried flowers for the past few years is Y4 per kan, it may be estimated that the total yield of 450 kan (about 3,720 lb.) for a period of five years brings in an income of Y1800. With the foregoing data the cost of production and average annual income per chobu may now be estimated:—

		Yen
Income over 5 years		1,800
Expenditure as shown in the foregoing table ..	786·50	
Cost of equipment	70·00	
Total cost of production over five years ..		856·50
Net income ..		943·50
Average annual income ..		188·70

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Apiculture

The following statement relating to experiments on the location of bee colonies (sun *versus* shade) is taken from a report on agricultural research work carried out in Palestine during the half-year ended December 31, 1937, which has been furnished by the Colonial Secretary.

An apiary consisting of 72 hives, divided equally into 12 rows, was so laid out on the eastern side of a Eucalyptus grove that the outside row (first row of hives) was 15 metres beyond the outer row of trees and free from any protection against the direct sun rays. The rows were placed at equal distances apart so that the fifth row was among the first row of trees and the sixth row among the third row of trees and subjected to the greatest amount of shade. Each row consisted of 9 standard single-wall Root hives and 3 Buckeye double-wall hives. All hives received identical care and management.

Data has been collected for the year October 1, 1936, to September 30, 1937, concerning consumption of sugar in all hives, condition of queens, bees and brood, temper of bees, quantity of comb foundation drawn, number of swarms and quantity of honey produced and the mortality of the colonies in each row.

From the results obtained it would appear that the placing of hives in the shade is much more desirable and practical than placing them in the open without any protection against the blazing sun. Particulars of the results are given below:—

(*a*) The average production of honey in the first row was 8.9 kilos per hive with a marked and continued increase in succeeding rows to 20.5 kilos in the sixth.

(*b*) An average of 2.6 swarms were produced per hive in the first row whereas 4.3 swarms per hive were produced in the sixth row.

(*c*) 5.9 full combs of foundation were drawn in the first row; the corresponding figure for the sixth row was 14.3 combs.

(*d*) As to mortality of bee colonies, 4 died in the first row and only 1 in the sixth row.

(*e*) Hives in the first row consumed 9.7 kilos of sugar each and in the sixth row 10.1 kilos.

(*f*) The temper of bees was much more easily aroused in those hives of the sixth row than in those of the first, but this might probably have been due to the fact that the colonies in the first two were much weaker throughout the entire year than those of the sixth.

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